5. OVERVIEW OF THE SCOS97-NARSTO FIELD STUDY

This section summarizes the proposed field measurement activities and the forecasting and decision-making protocol for the SCOS97-NARSTO field study. The air quality and meteorological measurement program includes measurements performed continuously over several months and intensive studies performed on a forecast basis during periods when ozone exceedances and transport are most expected. The proposed measurement program is summarized in this section and cost estimates are itemized in Section 12.

The proposed measurement program is designed to meet the goals and technical objectives of the sponsors and incorporates the following design guidelines that have evolved from technical, logistical and cost considerations in prior studies.

- SCOS97-NARSTO is designed to provide the aerometric and emission databases needed to apply and evaluate atmospheric and air quality simulation models, and to quantify the contributions of upwind and downwind air basins to exceedances of ozone standards in southern California. While urban-scale and regional model applications are emphasized in this study, the SCOS97-NARSTO database is also designed to support the data requirements of both modelers and data analysts. Air quality models require initial and boundary measurements for chemical concentrations. Meteorological models require sufficient three-dimensional wind, temperature, and relative humidity measurements for data assimilation. Data analysts require sufficient three-dimensional air quality and meteorological data within the study region to resolve the main features of the flows and the spatial and temporal pollutant distributions. The data acquired for analyses can be used for diagnostic purposes to help identify problems with and to improve models.

- Several of the measurement techniques (e.g., aircraft, VOC, and radiosonde measurements) are labor intensive and require costly expendables. Both logistical and cost considerations preclude intensive three-dimensional measurements continuously throughout a complete season. Since the main focus of the study is on ozone, the intensive measurements will be made on days leading up to and during ozone episodes and specific ozone transport scenarios.

- The focus on episode days requires a good understanding of the meteorology leading up to episodes and a forecasting protocol that has been tested and evaluated. The major logistical requirements of a study of this magnitude require a tentative decision to launch an intensive operating period 48 to 72 hours in advance. Since episodes are not guaranteed to be a frequent occurrence and the forecast may not always be accurate, the study must be designed to sample several episodes and to last for a duration that is adequate to ensure several measurement opportunities.

- Although the study focuses on ozone episodes, it is important to put the episodes in perspective and to understand the differences between episode and non-episode days as well as the representativeness of the episodes. Since episodes are caused by changes in meteorology, it is useful to document both the meteorology and air quality on non-episode days. For this reason, continuous instruments are included that can document upper air meteorology, and continuous air quality and meteorological measurements are scheduled to be made throughout the study period. A network of radar wind profilers will allow increased confidence in assigning qualitative transport characterization (i.e., overwhelming, significant, or inconsequential) throughout the study period.

- The 1987 Southern California Air Quality Study clearly identified the need for meteorology and air quality aloft in the boundary layer throughout the study region. Many of the transport phenomena and important reservoirs of ozone and ozone precursors are found aloft. SCOS97 is designed to include extensive three-dimensional measurements and simulations because the terrain in the study area is complex and because the flow field is likely to be strongly influenced by land-ocean interactions. Several upper air meteorological measurements are proposed at strategic locations to elucidate this flow field.

- The measurements are designed such that no one measurement system or individual measurement is critical to the success of the program. The measurement network should be dense enough that the loss of any one instrument or sampler will not substantially change analysis or modeling results. The study should be designed such that a greater number of intensive days than minimally necessary for modeling are included. This helps minimize the influence of atypical weather during the field program and decreases the probability of equipment being broken or unavailable on a day selected for modeling. Most measurements should be consistent in location and time for all intensive study days and during the entire study period (i.e., no movement of measurements). In this way, one day can be compared to another. Continuous measurements should be designed to make use of the existing monitoring networks to the extent possible.

- Aerosol measurements- photochemistry/ozone and aerosol formation interactions.

5.1 Geographic Scope

SCOS97 will encompass the South Coast (SoCAB), San Diego (SDAB), South Central Coast (SCCAB), and Southeast Desert (SEDAB) Air Basins extending to northern Mexico to the south and to Nevada and Arizona to the east, as shown in Figure 2-1. The northern boundary of this study will include the southern portion of the San Joaquin Valley Air Basin (SJVAB). The western boundary will be defined by the results of measurements that identify where clean air typically exists over the Pacific Ocean. Ozone transport in southern California appears to be an important contributor to ozone exceedances, but these contributions have not been quantified. It was not previously possible to model the entirety of southern California, shown in Figure 2-1, owing to the limits of computational resources and the associated costs. More recently, computational power has increased while costs have declined, making regional modeling feasible. Another limitation has been the dearth of three-dimensional aerometric measurements to support regional modeling in the complex terrain of southern California, shown in Figure 2-2.

5.2 Study Period

The SCOS97 field measurement program will be conducted during a five-month period from June 1, 1997 to October 31, 1997. This study period corresponds to the majority of elevated ozone levels observed in southern California during previous years. Continuous surface and upper air meteorological and air quality measurements will be made hourly throughout this study period. The PAMS monitoring program, which currently operates annually from July 1 to September 30, will operate from June 1 to October 31, 1997.

Additional measurements will be made during intensive operational periods (IOPs) on a forecast basis for two to four consecutive days. Forecasts are prepared each day during the five-month period and IOP measurement groups are on standby. The budget for SCOS97 allows for up to 15 days total IOP days. With a minimum of two days per IOP, the maximum number of IOPs is seven. Five IOPs is more likely, with an average IOP duration of three days. The conceptual model for this study defines five categories of meteorological conditions, called scenarios, which are associated with ozone episodes and ozone transport in southern California. Intensive measurements will be made during these scenarios. The five scenarios (Section 2.5) in order of priority as specified by the SCOS97 Technical Committee, and the periods of highest probability of their occurrence are as follows:

1. SoCAB Ozone Maximum (Type 1 IOP) — Late July to end of August
2. Upper-Level Transport to San Diego (Type 2 IOP) — Late July to end of August
3. Secondary SoCAB Ozone Maximum (Type 3 IOP) — Late July to end of August
4. Eddy Transport to Ventura after SoCAB Maximum (Type 4 IOP) — June
5. Off-Shore Transport to San Diego (Type 5 IOP) — September to October

The five meteorological scenarios of interest fall within three overlapping periods which together span the entire ozone season. Types 1, 2, and 3 can occur throughout the summer, but have the highest probability of occurrence in mid-summer. Type 4 typically occurs during the late spring to early summer, while Type 5 occurs from late summer to early fall. Because costs that are incurred during standby status can be substantial (e.g., maintaining aircraft crews on a ready status), specific time windows called intensive periods (IPs) have been considered. The IPs would correspond to periods of highest frequency of occurrences of specific ozone episodes and ozone transport scenarios of interest. The IPs would maximize the probability of capturing specific scenarios of interest and minimize extended periods on standby. For example, one alternative would be two one-month IPs, from July 15 through August 15 and from September 15 through October 15. This alternative would likely miss Type 4 conditions, which are more infrequent than other meteorological conditions of interest, may be more difficult to forecast accurately, and often result in marginal ozone levels in the SCCAB. However, Type 4 conditions may be important in fostering transport from the SoCAB to the SCCAB. Furthermore, shorter IPs run the risk of missing major episodes of any IOP type that may have occurred outside the IP time windows. Therefore, IPs are not proposed in this plan.

The U.S. Navy's EOPACE intensive measurement period is currently scheduled for August 25 to September 5, 1997. The EOPACE will acquire air quality and meteorological measurements in coastal and offshore locations, thereby providing data at the coastal boundary of the SCOS97 modeling domain without major additional expenditures. The scheduled EOPACE intensive period may be too late to capture Type 4 conditions and too early to capture Type 5 conditions, but it is near the end of the period when Types 1, 2, and 3 are most likely.

5.3 Forecast Protocol

The decision to declare an IOP will be based on daily meteorological and air quality forecasts. These forecasts and other information on current conditions and operational status will be used to decide whether intensive sampling would be performed the next day. The protocol for the daily forecasts were tested by the forecast team during the summer of 1996 and further refined for application during SCOS97.

The Forecast Team consists of representatives from the ARB, the SDAPCD, the SCAQMD, the U.S. Navy, and the VCAPCD, and is chaired by Joe Cassmassi of the SCAQMD. Weekday practice forecasts begin Tuesday, May 6, and weekend forecasts start Saturday, June 7 to coincide with the aloft measurement comparisons that are scheduled during the week of June 9-14. The forecast protocol is as follows.

<u>Day 0</u>

14:30 The Forecast Team provides a 2-day forecast (for Day 1 and Day 2) with expectations for 3 to 5 days. Data collection will begin on Day 2, and Day 3 will be the first high ozone day.

15:00 Two members of the Forecast Team, the lead forecaster and one other Team member, meet with the Field Program Management Committee to describe the forecast.

15:30 The Field Program Management Committee announces a "Go" decision, and the Field Managers alert all groups taking measurements.

16:00 Contractors make plans to be on-site and being sampling by 0500 PDT (1200 Z) on Day 2. They purchase plane tickets, and make reservations. Once sampling begins, it will continue for at least 6 hours. To coincide with the NWS, the 4-per-day rawinsonde and ozonesonde sampling schedule will be 1200 Z (0500 PDT), 1800 Z (1100 PDT), 0000Z (1700 PDT), and 0600 Z (2300 PDT).

<u>Day 1</u>

09:30 The Forecast Team meets to update the forecast of the previous day on which the "Go" decision was based.

10:00 Two members of the Forecast Team meet with the Field Program Management Committee to review the updated forecast and the "Go" decision from the previous day.

10:30 The Field Program Management Committee confirms the "Go" decision from the previous day. If they cancel the "Go" decision, the Field Managers communicate to field crews so they can cancel travel plans.

14:30 The Forecast Team meets to provide a 2-day forecast with expectations for 3 to 5 days. The prognosis for Day 3 will be confirmed.

15:00 Two members of the Forecast Team meet with the Field Program Management Committee to review the updated forecast and the "Go" decision from the previous day.

15:30 The Field Program Management Committee confirms the "Go" decision for Day 3. If they cancel the "Go" decision, it can be done here without any intensive sampling being conducted. However, it must be understood that at this point contract personnel will be in transit and recall will lose some resources. The Field Managers relay the "Go" decision or report the cancel decision to all groups taking measurements.

Day 2 (and repeated through the end of the intensive operational period)

05:00 Intensive sampling begins.

09:30 The Forecast Team meets to update the forecast of the previous day on which the "Go" decision was based.

10:00 Two members of the Forecast Team meet with the Field Program Management Committee to review the updated forecast and the "Go" decision from the previous day.

10:30 The Field Program Management Committee confirms the "Go" decision from the previous day. If the Field Program Management Committee decides to cancel the "Go" decision, the Field Managers communicate the decision to the Field Managers so that field crews can stop. The last field samples are collected at 11:00 PDT.

14:30 The Forecast Team meets to provide a 2-day forecast with expectations for 3 to 5 days.

15:00 Two members of the Forecast Team meet with the Field Program Management Committee to review the updated forecast and the "Go" decision from the previous day.

15:30 The Field Program Management Committee confirms the "Go" decision for Day 3. If the Field Program Management Committee decides to cancel, sampling will continue at least through 1700 PDT. However, the Field Program Management Committee may direct that sampling continue through a specified time (e.g., 23:00 PDT to complete a diurnal cycle).

16:00 The Field Program Management Committee chairman passes the decision to the Field Managers who verify the "Go" decision or report the cancel decision to the contractors. If the "Go" decision is verified, sampling will continue until 11:00 PDT on the following day.

5.3.1 IOP Decision Protocol and Criteria

Every Monday and Thursday morning, between IOPs, each measurement group will e-mail or fax the appropriate Field Manager with their readiness status. A return note from the Field Managers will acknowledge that the information was received. These will be compiled and made available to the Field Program Management Committee for their daily afternoon conference call, and then posted on the SCAQMD web page. Any changes in status should be e-mailed or faxed immediately to the Field Manager, preferably before the daily Field Program Management Committee conference call.

After each Field Program Management Committee conference call, the Go or no-Go decision will be e-mailed or faxed to all the measurement groups. The information will also be available on the SCAQMD web site and as a message on a phone line dedicated to the field campaign. Individuals that need long lead times for travel arrangements will be contacted by phone. A return note to the Field Managers will acknowledge that the information was received, and note any changes in readiness status.

During the IOPs, the Field Managers will communicate the Go and No-Go decisions twice per day. An attempt will be made to contact everyone by phone if an IOP is canceled. During the IOP, each measurement group will contact the Field Managers at least every morning to convey information on problems in the field. These will be compiled and made available to the Field Program Management Committee for their daily conference calls.

After the IOP, the measurement group will write brief summaries of the field operations (e.g., measurement taken, unusual conditions encountered, equipment breakdowns, logistical problems to be solved) to the Field Manager.

While it is preferable to have all measurement systems operational for each IOP, and every attempt will be made to assure their operability, the program has been designed to allow an IOP to proceed even if some equipment is inoperable. A critical level of operability needs to be defined, however, beyond which an IOP would not acquire enough data to be useful. Maintenance and re-supply between IOPs needs to be considered as well. Depending on the number of consecutive total IOP days just completed and the number of aircraft used, the aircraft equipment operators need one or two days without sampling before starting another IOP. In addition, routine maintenance, which is a function of flight hours, is required. In addition to field readiness and information from the Forecast Team, specific thresholds associated with elevated ozone for each of the five meteorological scenarios should be selected based on the information obtained from the trial forecasting of summer 1996. The criteria that will be used by the Field Program Management Committee to decide whether or not to conduct intensive sampling will be refined prior to the field campaign.

5.4 SCOS97 Study Period Measurements

The continuous surface-based measurements will be made daily throughout the study season. The study period monitoring network consists of existing surface air quality, surface meteorology, and upper-air meteorology monitoring sites, as well as new sites added specifically for this study. The continuous data are used to:

- Characterize or describe the spatial and temporal distribution of pollutant concentrations and meteorological parameters on days leading up to and during ozone episodes and for documenting the frequency of occurrence of different measures for comparison with prior and later years.

- Document the transport of pollutants and precursors between major source regions and non-attainment receptor areas, between the major source regions, and between offshore and onshore, during both episode and non-episode conditions.

- Provide initial and boundary conditions for air quality model initialization, and input data for data assimilation by prognostic meteorological models.

- Provide data within the modeling domain to evaluate the output of the models and to diagnose deviations of model assumptions from reality.

5.4.1 Existing Surface Air Quality and Meteorological Monitoring Sites

Currently operating ozone and NO_X monitoring sites are identified with respect to location, name, and associated measurements in Table 5-1 (see Appendix A for additional site information). All of these sites are operated by state and local air quality districts, are subject to quality assurance programs, and report their measurements into a common database. Figure 5-1 shows the relative location of currently operating ozone and NOx monitoring sites. This network is adequate to characterize O_3 and NO_X at receptor sites in the study region. Photochemical Assessment Monitoring Stations (PAMS) hydrocarbon and carbonyl compound sampling will be conducted at 13 sites from July 1, 1997 to September 30, 1997, according to the schedule shown in Table 5-2. Additionally, PAMS VOC monitoring will be needed during IOPs that occur in June and October 1997. Ozone information is also provided by the U.S. Naval Air Warfare Center which operates ozone analyzers at Point Mugu and on nearby Laguna Peak to document correlations between ozone and wind direction.

Many of the air quality monitoring sites also measure wind and temperature. In addition to those air quality sites that measure meteorology, there is an extensive network of existing surface meteorological sites spread throughout the study area, including offshore locations on islands, oil platforms and instrumented environmental buoys. These sites generally provide continuous measurement of wind speed and direction with an averaging time of one hour or less. They are operated by military and civilian airports, air quality districts, the National Weather Service, and others. Appendix B lists these surface meteorological monitoring sites. Figure 5-2 shows the locations of existing meteorological measurement sites in the SCOS-NARSTO domain. The existing network of surface measurements is adequate to determine some surface transport patterns, but it is not sufficient to determine winds aloft or some mesometeorological phenomena. Supplemental air quality and meteorological monitoring that are planned during the SCOS97-NARSTO field measurement program are identified in the following section.

5.4.2 Supplemental Air Quality and Meteorological Measurements

The existing surface air quality and meteorological monitoring network will be supplemented by additional measurements made specifically during the SCOS97-NARSTO study period. Table 5-3 provides a summary of the supplemental surface air quality and meteorological measurements that will be made by contractors and by in-kind support from the U.S. Environmental Protection Agency.

The majority of the supplemental surface air quality measurements are in connection with collection of volatile organic compounds (VOC) samples and continuous measurements of ozone, nitric oxide (NO), nitrogen dioxide (NO_2), oxides of nitrogen (NO_X), total oxidized nitrogen (NO_y), and peroxyacetylnitrate (PAN), especially in critical areas of the study domain (e.g., transport corridors) where these measurements are not currently being made. Accurate quantification of NO and NO_2 is important because the inter-conversion of NO and NO_2 is the photochemical mechanism for the formation and destruction of ozone in the troposphere. Organic nitrates such as PAN provide a means to transport NO_X from source regions to downwind locations. Total oxidized nitrogen (NO_y) provides an estimate of the total nitrogen budget and photochemical aging of the air mass. Figure 5-3 shows the locations of the supplemental ozone and nitrogenous species measurement sites. As described in the previous section, current PAMS networks in southern California do not measure hydrocarbons and carbonyl compounds on a daily basis, with the exception of the Pico Rivera Type 2 site in the SoCAB (the automated GC is scheduled to come on-line at Burbank in June 1997). Supplemental measurements are required for the SCOS97 study during multi-day intensives in order to obtain VOC measurements throughout the IOP. VCAPCD and SDAPCD will supplement their existing sampling schedules to include all SCOS97 IOP days. Because of their larger network, the SCAQMD will not be able to supplement their existing sampling schedule. The supplemental measurements for SCOS97-NARSTO include additional PAMS VOC measurements in the SoCAB. Figure 5-4 shows the locations of the PAMS and supplemental VOC measurement sites.

The extreme downwind PAMS site in SoCAB is scheduled for deployment in 1998, one year after the SCOS97 study. Lancaster has been tentatively selected for this site. The MDAPCD is considering VOC measurements in the Lancanster during SCOS97 to document transport of VOC through Soledad Canyon at Hesperia to document transport of VOC through Cajon Pass. The two "tracers of opportunity", perchloroethylene and methylchloroform will be measured semi-continuously near the Barstow area.

The supplemental surface air quality measurements also include specialized measurements by several investigators. These measurements include radiocarbon, semi-continuous speciated C_2 to C_{11} hydrocarbons, biogenic organic compounds, multifunctional carbonyl compounds, total reactive carbon and polycyclic aromatic hydrocarbons. Other than the automated gas chromatographic hydrocarbon analysis by EPA, no system or performance audits are planned for these special measurements. In most cases, air quality data from the SCOS97 core measurements will allow for data validation checks by individual investigators. Table 5-4 provides additional information concerning the supplemental surface air quality and meteorological measurements.

5.4.3 Aloft Meteorological Measurements

To obtain information on temperature, relative humidity, and wind at various levels of the atmosphere above ground level, meteorological soundings will be used. Routine, twice-per-day radiosondes will provide in situ measurements of pressure, temperature, humidity, and wind speed and direction at various altitudes above ground. Two types of remote sounding, radar wind profilers and Doppler acoustic sounders, will provide continuous measurements of upper-air winds during the entire four-month SCOS97-NARSTO measurement period.

Table 5-1
Routine Air Quality Monitoring Sites in Southern California

Site ID	Air Basin	County	Data Source	Site Name	Variables Measured						
					O3	NO	NOx	CO	THC	CH4	NMHC
ARVN	SJVAB	Kern	CARB	ARVIN-20401 BEAR MTN BLVD	x	x	x				
BKGS	SJVAB	Kern	SJVUCD	BAKERSFIELD-1138 GOLDEN STATE	x	x	x	x	x	x	x
BLFC	SJVAB	Kern	CARB	BAKERSFIELD-5558 CALIFORNIA ST	x	x	x	x	x	x	x
EDSN	SJVAB	Kern	CARB	EDISON-JOHNSON FARM	x	x	x				x
OLDL	SJVAB	Kern	CARB	OILDALE-3311 MANOR ST	x	x	x		x	x	x
ARGR	SCCAB	San Luis Obispo	XONTEC	ARROYO GRANDE-RALCOA WAY					x	x	x
ATAS	SCCAB	San Luis Obispo	SLOCO	ATASCADERO-6005 LEWIS AVE	x	x	x				
GCTY	SCCAB	San Luis Obispo	SLOCO	GROVER CITY-9 LE SAGE DR	x	x	x				
MOBY	SCCAB	San Luis Obispo	SLOCO	MORRO BAY-MORRO BAY BL & KERNR	x						
NIPO	SCCAB	San Luis Obispo	UNOCAL	NIPOMO-1300 GUADALUPE RD	x						
NPSW	SCCAB	San Luis Obispo	SLOCO	NIPOMO-148 S WILSON ST	x	x	x				
PSRB	SCCAB	San Luis Obispo	CARB	PASO ROBLES-235 SANTA FE AVE	x						
SLPL	SCCAB	San Luis Obispo	EMC	SAN LUIS OBISOP-7020 LEWIS		x	x		x		
SLOM	SCCAB	San Luis Obispo	CARB	SAN LUIS OBISPO-1160 MARSH ST	x	x	x	x	x		
CPGB	SCCAB	Santa Barbara	CHVRON	CARPINTERIA-GOBERNADOR RD	x	x	x				
ECSP	SCCAB	Santa Barbara	SBAPCD	EL CAPITAN STATE PARK	x	x	x		x		
GAVE	SCCAB	Santa Barbara	CHVRON	GAVIOTA EAST-N OF CHEVRON PLAN	x	x	x		x		
GAVW	SCCAB	Santa Barbara	CHVRON	GAVIOTA WEST-NW OF CHEVRON PLA	x	x	x		x		
GTCA	SCCAB	Santa Barbara	TEXACO	GAVIOTA-GTC A 5 MI SW OF PLT	x	x	x				
GTCC	SCCAB	Santa Barbara	TEXACO	GAVIOTA-GTC C 1 MI E OF PLANT	x	x	x		x		
GLWF	SCCAB	Santa Barbara	SBAPCD	GOLETA-380 W FAIRVIEW AVE	x	x	x	x			
LPSH	SCCAB	Santa Barbara	SBAPCD	LOMPOC-128 S 'H' ST	x	x	x	x			
LPHS	SCCAB	Santa Barbara	UNOCAL	LOMPOC-HS&P FACILITY 500 M SW	x	x	x		x		
LOSP	SCCAB	Santa Barbara	UNOCAL	LOS PADRES NF-PARADISE RD	x	x	x				
GTCB	SCCAB	Santa Barbara	TEXACO	NOJOQUI PASS-GTC B HWY 101	x	x	x				
PTAR	SCCAB	Santa Barbara	UNOCAL	POINT ARGUELLO-NE OF SLC	x	x	x		x		
PTCL	SCCAB	Santa Barbara	CHVRON	POINT CONCEPTION LIGHTHOUSE	x	x	x				
SBWC	SCCAB	Santa Barbara	CARB	SANTA BARBARA-3 W. CARRILLO ST	x	x	x	x			
SMSB	SCCAB	Santa Barbara	CARB	SANTA MARIA-500 S BROADWAY	x	x	x				
SMBB	SCCAB	Santa Barbara	UNOCAL	SANTA MARIA-BATTLES BETTERAVIA	x	x	x		x		
SYAP	SCCAB	Santa Barbara	SBAPCD	SANTA YNEZ-AIRPORT RD	x						
UCSB	SCCAB	Santa Barbara	EXXON	UCSB WEST CAMPUS-ARCO TANK, IS	x	x	x		x		
VBPP	SCCAB	Santa Barbara	VBGAFB	VANDENBERG AFB-STS POWER PLANT	x	x	x	x	x		
ELRO	SCCAB	Ventura	VCAPCD	EL RIO-RIO MESA SCHOOL	x	x	x	x	x	x	x
EMMA	SCCAB	Ventura	VCAPCD	EMMA WOOD STATE BEACH	x	x	x				
THOS	SCCAB	Ventura	CARB	OAK VIEW-5500 CASITAS PASS RD	x	x	x		x		
	SCCAB	Ventura	VCAPCD	OJAI - OJAI AVENUE	x	x	x				
OJAI	SCCAB	Ventura	VCAPCD	OJAI-1768 MARICOPA HIWY	x	x	x				
PRTG	SCCAB	Ventura	VCAPCD	PIRU-2SW, 2815 TELEGRAPH RD	x						
SVAL	SCCAB	Ventura	VCAPCD	SIMI VALLEY-5400 COCHRAN ST	x	x	x	x	x	x	x
TOMP	SCCAB	Ventura	VCAPCD	THOUSAND OAKS-9 2323 MOORPARK	x	x	x				
AZSA	SoCAB	Los Angeles	SCAQMD	AZUSA-803 N LOREN AVE	x	x	x	x	x	x	x
BRBK	SoCAB	Los Angeles	SCAQMD	BURBANK-228 W PALM AVE	x	x	x	x	x		x
GLDR	SoCAB	Los Angeles	SCAQMD	GLENDORA-840 LAUREL	x	x	x				
HAWH	SoCAB	Los Angeles	SCAQMD	HAWTHORNE-5234 W. 120TH ST	x	x	x	x			
NLGB	SoCAB	Los Angeles	SCAQMD	LONG BEACH-3648 N LONG BEACH	x	x	x	x	x	x	x
LANM	SoCAB	Los Angeles	SCAQMD	LOS ANGELES-1630 N MAIN ST	x	x	x	x	x	x	x
LYNW	SoCAB	Los Angeles	SCAQMD	LYNWOOD-11220 LONG BEACH BLVD	x	x	x	x	x	x	
PDSW	SoCAB	Los Angeles	SCAQMD	PASADENA-752 S. WILSON AVE	x	x	x	x			
PICO	SoCAB	Los Angeles	SCAQMD	PICO RIVERA-3713 SAN GABRIEL	x	x	x	x	x		x
POMA	SoCAB	Los Angeles	SCAQMD	POMONA-924 N GAREY AVE	x	x	x	x	x		x
RSDA	SoCAB	Los Angeles	SCAQMD	RESEDA-18330 GAULT ST	x	x	x	x	x		
	SoCAB	Los Angeles	SCAQMD	SAN DIMAS-GLADSTONE (open by 1/96)	x	x	x				
CLAR	SoCAB	Los Angeles	SCAQMD	SANTA CLARITA-SAN FERNANDO RD	x	x	x	x			

Table 5-1 (continued)
Routine Air Quality Monitoring Sites in Southern California

Site ID	Air Basin	County	Data Source	Site Name	Variables Measured						
					O3	NO	NOx	CO	THC	CH4	NMHC
ANAH	SoCAB	Orange	SCAQMD	ANAHIEM-1610 S HARBOR BLVD	x	x	x	x	x		
CMMV	SoCAB	Orange	SCAQMD	COSTA MESA-2850 MESA VERDE DR	x	x	x	x			
ELTR	SoCAB	Orange	SCAQMD	EL TORO-23022 EL TORO RD	x	x	x	x	x		
LHAB	SoCAB	Orange	SCAQMD	LA HABRA-621 W. LAMBERT	x	x	x	x	x		
HEMT	SoCAB	Riverside	SCAQMD	HEMET-880 STATE ST	x						
LELS	SoCAB	Riverside	SCAQMD	LAKE ELSINORE-506 W FLINT ST	x	x	x				
	SoCAB	Riverside	SCAQMD	MIRA LOMA-BELLEGRAVE AVE (by 1/96)	x						
PERR	SoCAB	Riverside	SCAQMD	PERRIS-237 .5 N "D" ST	x						
RIVM	SoCAB	Riverside	SCAQMD	RIVERSIDE-7002 MAGNOLIA AVE		x	x	x	x		
RUBI	SoCAB	Riverside	SCAQMD	RUBIDOUX-5888 MISSION BLVD	x	x	x	x	x	x	
TCCC	SoCAB	Riverside	SCAQMD	TEMECULA-COUNTY CENTER	x	x	x	x			
UCDC	SoCAB	Riverside	RIVER	UC RIVERSIDE-4919 CANYON CREST	x						
LGRE	SoCAB	San Bernardino	SCAQMD	CRESTLINE-LAKE GREGORY-LAKE DR	x						
FONT	SoCAB	San Bernardino	SCAQMD	FONTANA-14360 ARROW BLVD	x	x	x				
	SoCAB	San Bernardino	SCAQMD	LAKE ARROWHEAD (Open by 1/96)	x	x	x				
RDLD	SoCAB	San Bernardino	SCAQMD	REDLANDS-DEARBORN	x						
SANB	SoCAB	San Bernardino	SCAQMD	SAN BERNARDINO-24302 4TH ST	x	x	x	x			
UL	SoCAB	San Bernardino	SCAQMD	UPLAND	x	x	x				
CLXC	SEDAB	Imperial	ICAPCD	CALEXICO-900 GRANT ST	x	x	x				
CALE	SEDAB	Imperial	CARB	CALEXICO-CALEXICO HS ETHEL ST	x	x	x	x			x
EC9S	SEDAB	Imperial	ICAPCD	EL CENTRO-150 9TH ST	x						
WEST	SEDAB	Imperial	ICAPCD	WESTMORLAND-202 W FIRST ST	x						
MOJP	SEDAB	Kern	CARB	MOJAVE-923 POOLE ST	x	x	x				
LANC	SEDAB	Los Angeles	SCAQMD	LANCASTER-315 W PONDERA ST	x	x	x	x			x
BANN	SEDAB	Riverside	SCAQMD	BANNING-135 N ALLESANDRO	x				x		x
INDO	SEDAB	Riverside	SCAQMD	INDIO-46-990 JACKSON ST	x						
PALM	SEDAB	Riverside	SCAQMD	PALM SPRINGS-FS 590 RACQUET CL	x	x	x	x	x		x
BARS	SEDAB	San Bernardino	MDAQMD	BARSTOW-401 MOUNTAIN VIEW	x	x	x	x			
HESP	SEDAB	San Bernardino	MDAQMD	HESPERIA-17288 OLIVE ST	x	x	x	x			
JOSH	SEDAB	San Bernardino	NPS	JOSHUA TREE NATIONAL MONUMENT	x						
PHEL	SEDAB	San Bernardino	MDAQMD	PHELAN-BEEKLEY & PHELAN RDS	x	x	x	x			
TRNA	SEDAB	San Bernardino	MDAQMD	TRONA-83732 TRONA ROAD	x	x	x				
29PM	SEDAB	San Bernardino	MDAQMD	TWENTYNINE PALMS-6136 ADOBE DR	x	x	x	x			
VICT	SEDAB	San Bernardino	MDAQMD	VICTORVILLE-14029 AMARGOSA RD	x	x	x	x			
ALPN	SDAB	San Diego	SDAQMD	ALPINE-2300 VICTORIA DR	x	x	x		x	x	
CHVT	SDAB	San Diego	SDAQMD	CHULA VISTA-80 E "J" ST	x	x	x	x	x		x
DMMC	SDAB	San Diego	SDAQMD	DEL MAR-MIRACOSTA COLLEGE	x						
ECAJ	SDAB	San Diego	SDAQMD	EL CAJON-1155 REDWOOD AVE	x	x	x	x	x	x	x
ESCO	SDAB	San Diego	SDAQMD	ESCONDIDO-600 E VALLEY PKWY	x	x	x	x	x		x
OCEA	SDAB	San Diego	SDAQMD	OCEANSIDE-1701 MISSION AVE	x	x	x	x	x		
OTAY	SDAB	San Diego	SDAQMD	OTAY-1100 PASEO INTERNATIONAL	x	x	x	x			
SDUN	SDAB	San Diego	SDAQMD	SAN DIEGO-1133 UNION ST				x			
SD12	SDAB	San Diego	SDAQMD	SAN DIEGO-330A 12TH AVE	x	x	x	x	x	x	x
SDOV	SDAB	San Diego	SDAQMD	SAN DIEGO-5555 OVERLAND AVE	x	x	x	x	x	x	x

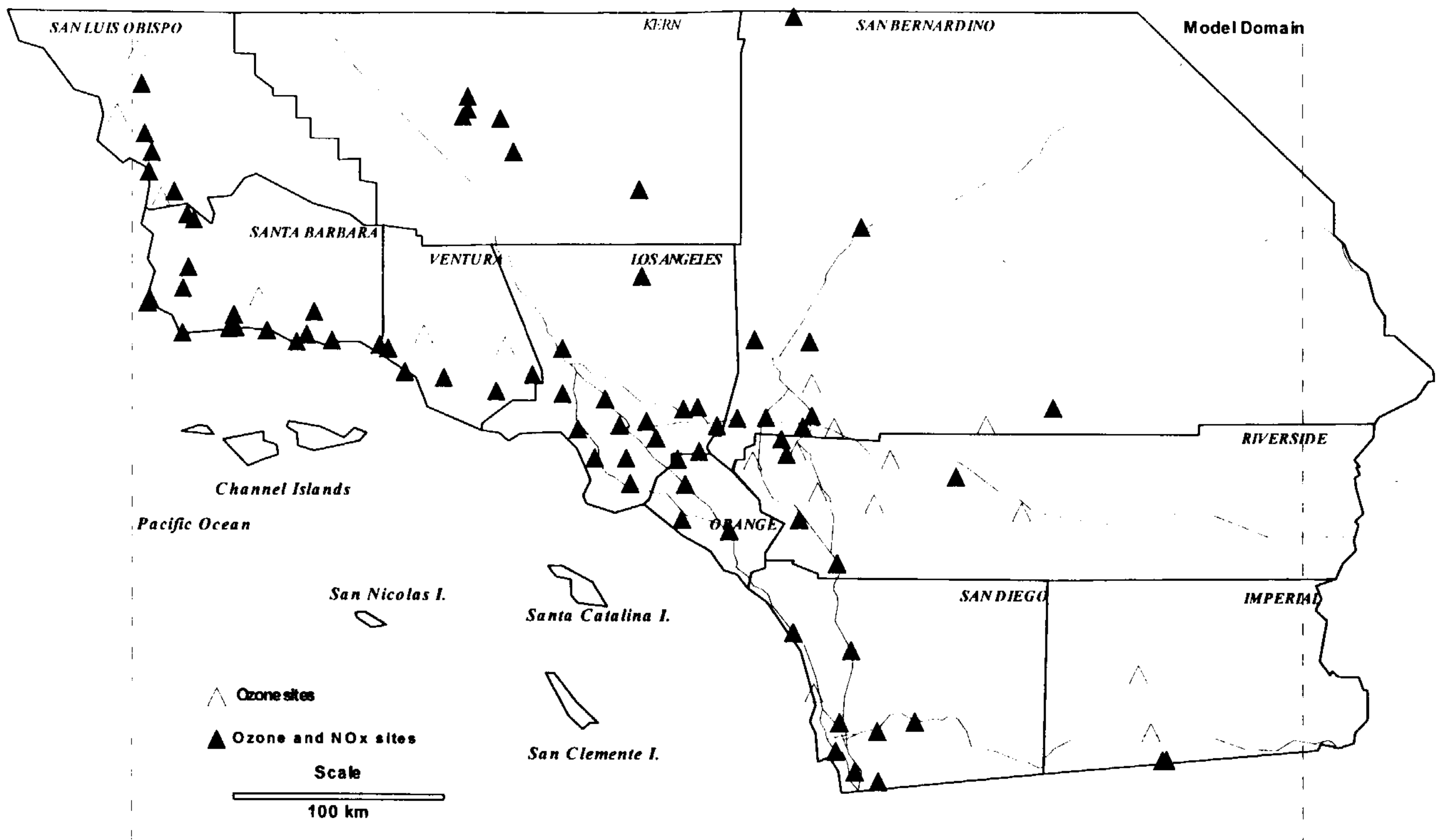

Figure 5-1. Currently operating ozone and NO_x monitoring sites.

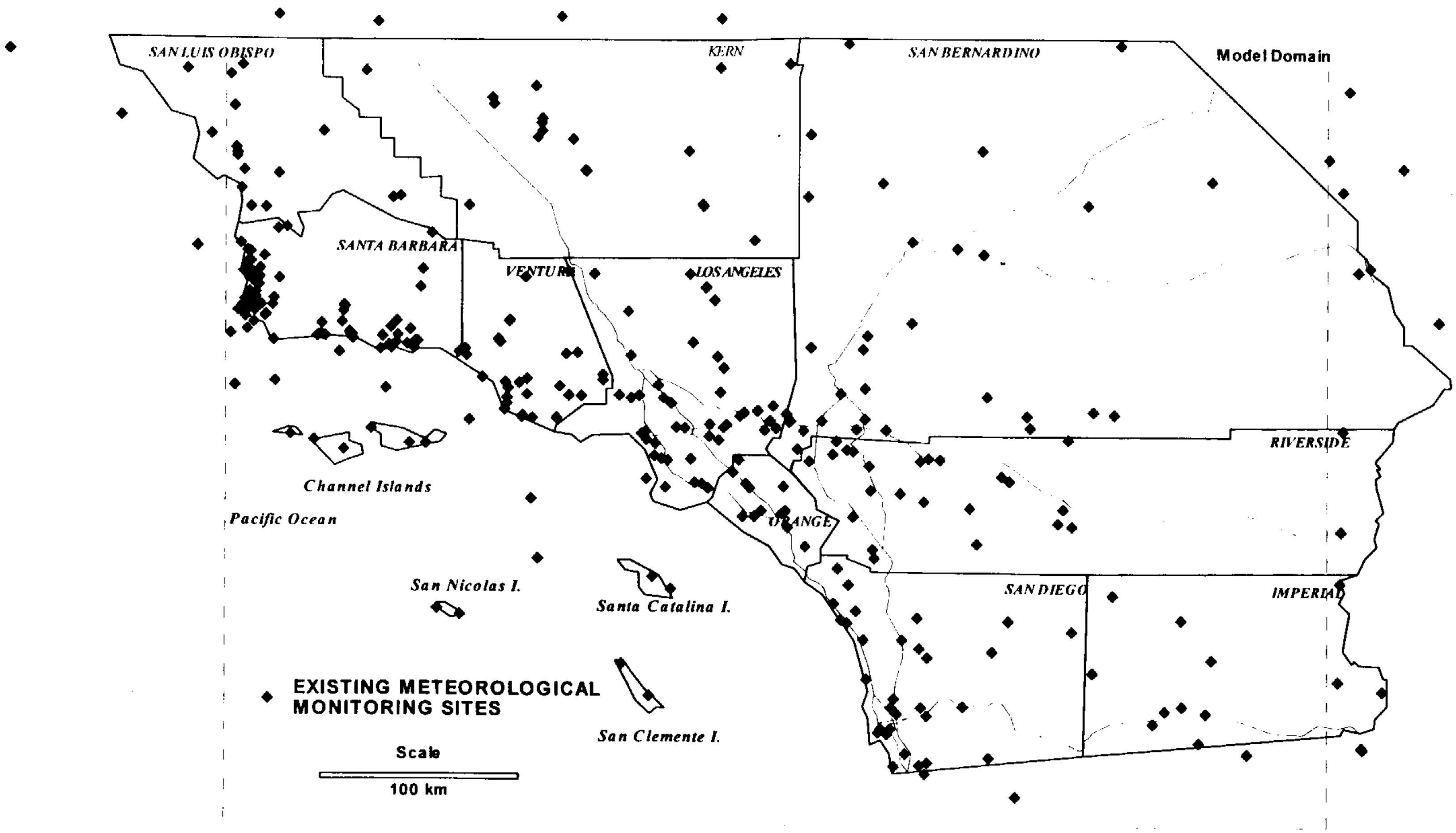

Figure 5-2. Existing surface meteorology measurement sites in the SCOS97-NARSTO domain.

Table 5-2
VOC Measurements at Photochemical Assessment Monitoring Stations (PAMS) in Southern California

Site Location	Type of Site	Year Deployed	VOC Method	Carbonyl Method	Frequency of VOC Measurements		Frequency of Carbonyl Measurements	
					EPA Rule	CA Alternative Plan	EPA Rule	CA Alternative Plan
Ventura County								
El Rio	2	1994	Canister/GC-FID	DNPH/HPLC	B	E, F	D	E
Simi Valley	3	1995	Canister/GC-FID		A or C	E, F		
Ventura - Emma Wood State Beach	1	1996	Canister/GC-FID		A or C	E, F		
South Coast Air Basin								
Pico Rivera	2	1994	Auto-GC	DNPH/HPLC	B	E, F	D	E
Upland	4	1994	Canister/GC-FID		A or C	E, F		
Azusa	3	1995	Canister/GC-FID		A or C	E, F		
Hawthorne	1	1996	Canister/GC-FID		A or C	E, F		
Burbank	2	1997?	Auto-GC	DNPH/HPLC	B	E, F	D	E
Southeast Desert Air Basin								
Upland	1	1994	Canister/GC-FID		A or C	E, F		
Banning	2	1995	Canister/GC-FID	DNPH/HPLC	A or C	E, F	D	E
Burbank	1	1997?	Auto-GC		A or C	E, F		
San Diego Air Basin								
El Cajon	2	1994	Canister/GC-FID	DNPH/HPLC	B	E, F	D	E
Alpine	3	1995	Canister/GC-FID		A or C	E, F		
Camp - Del Mar	1	1996	Canister/GC-FID		A or C	E, F		
San Diego - Overland	2	1994	Canister/GC-FID	DNPH/HPLC	B	E, F	D	E

Type 1 - Upwind background.
Type 2 - Maximum precursor emissions (typically located immediately downwind of the central business district).
Type 3 - Maximum ozone concentration.
Type 4 - Extreme downwind transported ozone area that may contribute to overwhelming transport in other areas.

A. Eight 3-hour samples (starting at midnight, PDT) every third day and one additional 24-hour sampler every sixth day during monitoring period (July-September).
B. Eight 3-hour samples (starting at midnight, PDT) every day during the monitoring period (July-Sept and one additional 24-hour sample every sixth day year-round.
C. Eight 3-hour samples on the 5 peak ozone days plus each previous day, eight 3-hour samples every sixth day, and one additional 24-hour sample every sixth day during monitoring period.
D. Eight 3-hour samples (starting at midnight, PDT) every day during the monitoring period (July-September).
E. Four 3-hour samples (3-6am, 6-9am, 1-4pm, 5-8pm, PDT) every third day during monitoring period (probably July-September), and four samples (6-9am, 9-noon, 1-4pm, 5- 8pm, PDT) per day on two consecutive days for five episodes during peak ozone season.
F. Continuous NMHC analyzer (e.g., Bendix 8202 or automated Preconcentration Direct injection Flame Ionization Detection gas chromatography, PDFID).

Table 5-3
SCOS97-NARSTO Supplemental Surface Air Quality and Meteorological Measurements

Site	Basin	Variables Measured														
		O_3	NO/NOx	NO_2	NOy	HNO_3	PAN/PPN	$CO/CO_2/CH_4$	C_2-C_{11} HC	MTBE	Carbonyl	Biogenic	Halocarb	Radicals	Met	Others
Ojai	SCCAB											(g)				
Santa Rosa Island	SCCAB	x													(2)	
Azusa	SoCAB		x	x	x	(a)	x	x	(c)	x	x		x	(d)		(e,f,i)
Banning	SoCAB		x		x	x										
Burbank	SoCAB		x		x	x										
Burbank	SoCAB							x	x	x	x					
Calabasas	SoCAB	x													(1)	
Catalina-Airport	SoCAB	x													(1)	
Catalina-Elevated	SoCAB	x			x										(1)	
El Cajon Pass	SoCAB	x			x										(1)	
El Monte	SoCAB											(g)				
LA North Main	SoCAB							x	x	x	x					(i)
Multiple Sites (h))	SoCAB															(h)
Palos Verdes	SoCAB	x													(1)	
Riverside	SoCAB		x		x	(b)										(i)
San Clemente	SoCAB							x	x	x	x					
San Gabriel Mountains	SoCAB											(g)				(e)
San Nicolas Island	SoCAB	x	x		x											
Simi Valley	SoCAB		x		x	x	x						x			
29 Palms	MDAB	x	x		x	x									(1)	
Barstow	MDAB	x	x		x	x							(j)		(1)	
Tehachepi Pas	MDAB	x													(1)	
Alpine	SDAB		x		x	x										
Black Mountain	SDAB	x													(2)	
Camp Pendleton	SDAB	x	x												(1)	
Fallbrook	SDAB	x													(2)	
Kearny Mesa	SDAB	x	x					CO	x		x				(1)	
Mount Soledad	SDAB	x	x		x	x			x		x				(2)	
Red Mountain	SDAB	x													(2)	
San Marcos Park	SDAB	x													(2)	
Valley Center	SDAB	x													(2)	
Mexicali, Mexico								x	x	x	x					
Tijuana, Mexico								x	x	x	x					

Table 5-3 (continued)

SCOS97-NARSTO Supplemental Surface Air Quality and Meteorological Measurements

Notes

(1) Surface WS, WD, T, and RH

(2) Surface WS, WD, and T.

(a) Collocated measurements by double diffusion denuder, tunable diode laser absorption spectroscopy, and NOy minus NOy - HNO3.

(b) Collocated measurements by double diffusion denuder and NOy minus NOy - HNO3.

(c) Collocated canister/GC-FID and automated semi-continuous gas chromatograph.

(d) HO, HO2, RO2 by laser fluorescence. Located at Azusa or Pico Rivera.

(e) radiocarbon

(f) multifunctional carbonyl compounds by PFBHA/ion trap MS

(g) Isoprene, MVK, and terpenes

(h) Total reactive carbon by cold trap & FID for four sites along transport trajectory in the SoCAB.

(i) Polycyclic aromatic hydrocarbons.

(j) Semi-continuous halocarbons

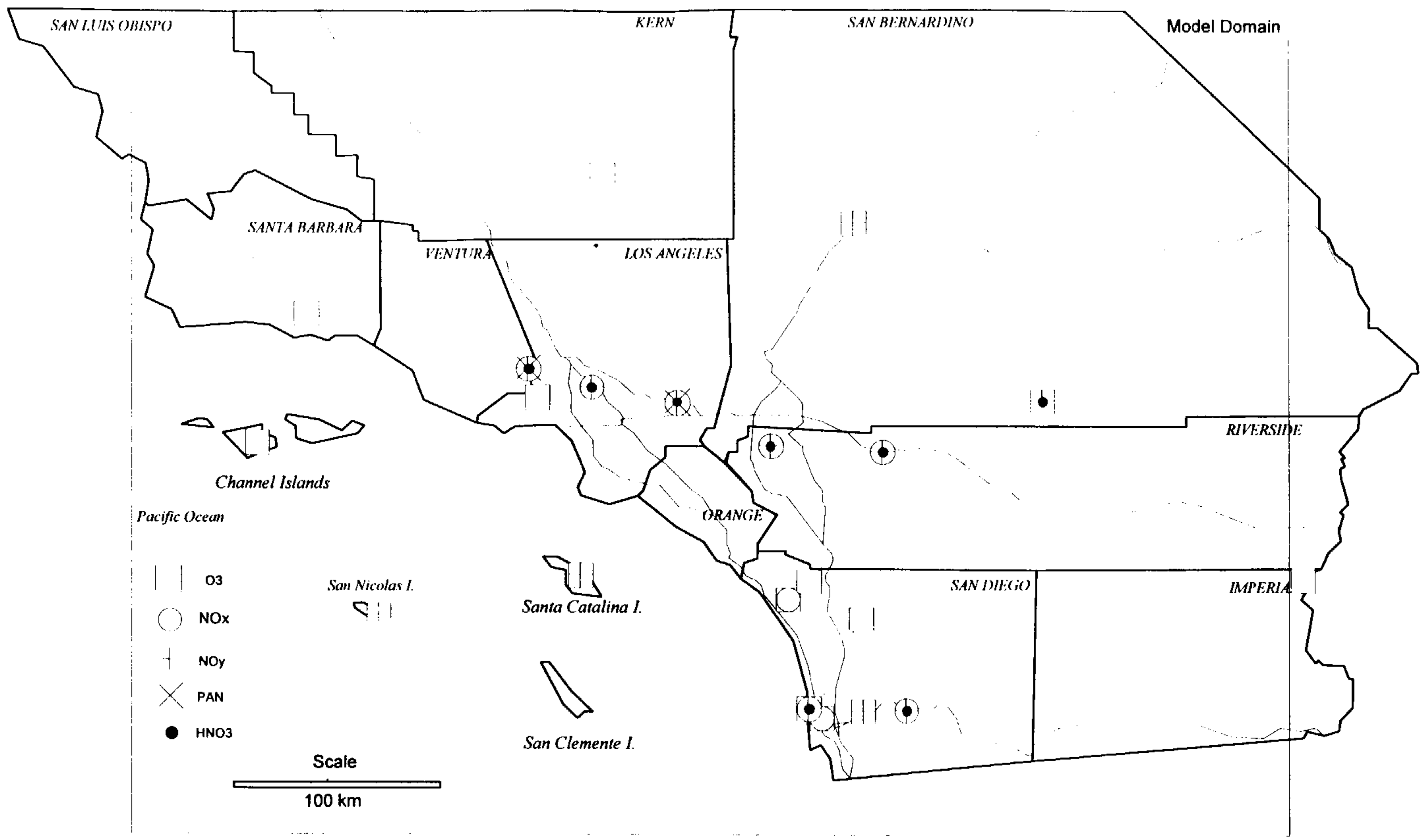

Figure 5-3. SCOS97-NARSTO supplemental ozone and nitrogenous species measurement sites.

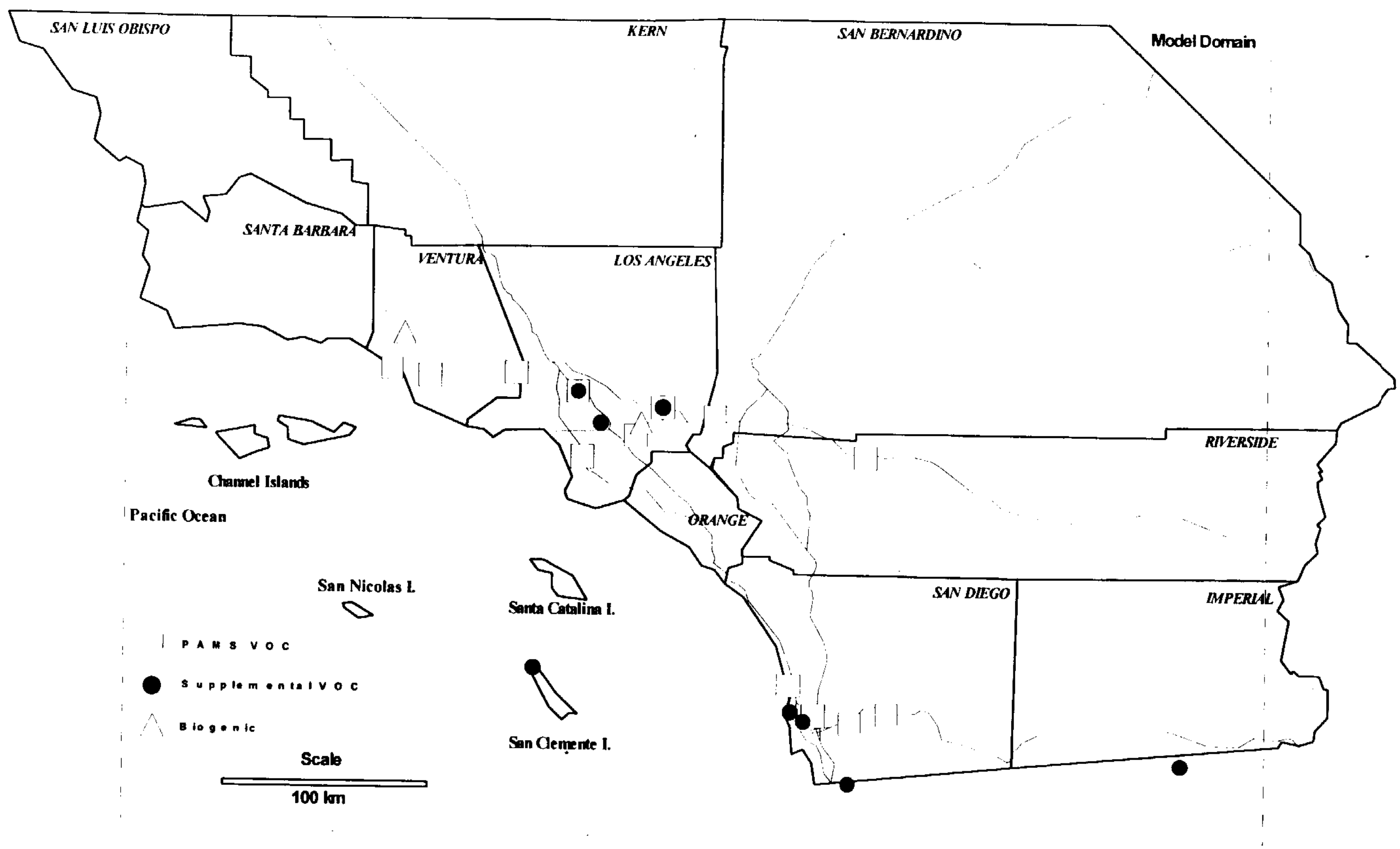

Figure 5-4. SCOS97-NARSTO volatile organic compound measurement sites.

Table 5-4
SCOS97-NARSTO Supplemental Surface Air Quality Measurements

Rec. #	Institution	Investigator	Species	Units	Measurement Device	Site Location	Air Basin
1	CE-CERT	Fitz, Dennis	HNO3 & Ammonia	ppbV	Double Diffusion Denuder	Azusa	SoCAB
2	CE-CERT	Fitz, Dennis	HNO3, NO2	ppbV	TDLAS	Azusa	SoCAB
3	UC Riverside	Arey, Janet	Night Time NO3-	ppbV	NO3 oxidation products	Azusa	SoCAB
4	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42CY & TECO 42/14	Azusa	SoCAB
5	DGA	Grosjean, Daniel	PAN, PPN, PERC, Meth Chlor	ppbV	Gas Chromotagraphy-ECD	Azusa	SoCAB
6	CE-CERT	Fitz, Dennis	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	Azusa	SoCAB
7	EPA	McClenny/Lewis	VOCs/radiocarbon	ppbC	Continuous GC	Azusa	SoCAB
8	PSU	O'Brien, Bob	HO, HO2, RO2	ppbV	Laser Fluorescence	Azusa (Pico Rivera?)	SoCAB
9	UCD	Charles, Judy	Multifunctional Carbonyls	ppbV	PFBHA/Ion trap MS	Azusa??	SoCAB
10	UC Riverside	Arey, Janet	Isoprene, Terpenes, MVK?	ppbC (ppbV)	canisters & FID	Banning	SoCAB
11	UC Riverside	Arey, Janet	Night Time NO3-	ppbV	NO3 oxidation products	Banning	SoCAB
12	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42CY & TECO 42	Banning	SoCAB
13	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42CY & TECO 42/14	Burbank	SoCAB
14	SCAQMD	Barbosa, Steve	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Continuous GC	Burbank	SoCAB
15	CE-CERT	Fitz, Dennis	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	Burbank??	SoCAB
16	Aervironment	Pankratz, David	ozone & WS, WD, T, RH	ppbV m/s mb & C	Dasibi & Std Met	Calabasas	SoCAB
17	Aervironment	Pankratz, David	ozone NOy & WS, WD, T, RH	ppbV m/s mb & C	TECO 42 CY Dasibi & Std Met	El Cajon Pass	SoCAB
18	UC Riverside	Arey, Janet	MVK?, oxydation biogenic HC	ppbC (ppbV)	canisters & FID	El Monte	SoCAB
19	UCLA	Paulson, Suzanne	Total reactive carbon	ppbC	cold trap & FID	Four sites along trajectory	SoCAB
20	SCAQMD	Barbosa, Steve	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	Hawthorne	SoCAB
21	UCR	Arey, Janet	PAH	ppbC	Hi-vol and PUF plugs	LA N. Main/Azusa/Riverside?	SoCAB
22	CE-CERT	Fitz, Dennis	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	LA North Main	SoCAB
23	Aervironment	Pankratz, David	ozone & WS, WD, T, RH	ppbV m/s mb & C	Dasibi & Std Met	Palos Verdes	SoCAB
24	SCAQMD	Barbosa, Steve	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Continuous GC	Pico Rivera	SoCAB
25	UC Riverside	Arey, Janet	Night Time NO3-	ppbV	NO3 oxidation products	Rivereside	SoCAB
26	CE-CERT	Fitz, Dennis	HNO3 & Ammonia	ppbV	Double Diffusion Denuder	Riverside	SoCAB
27	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42 + Moly Converter	Riverside	SoCAB
28	CE-CERT	Fitz, Dennis	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	San Clemente	SoCAB
29	UC Riverside	Arey, Janet	Isoprene, Terpenes, MVK?	ppbC (ppbV)	canisters & FID	San Gabriel Mt Peaks	SoCAB
30	EPA	Lewis	radiocarbon	ppbC	canisters	San Gabriel Mt Peaks	SoCAB
31	CE-CERT	Fitz, Dennis	NOy, NO & Ozone	ppbV	TECO 42CY & Dasibi	San Nicolas Island	SoCAB
32	Aervironment	Pankratz, David	ozone & WS, WD, T, RH	ppbV m/s mb & C	Dasibi & Std Met	Santa Catalina-Airport	SoCAB
33	Aervironment	Pankratz, David	ozone NOy & WS, WD, T, RH	ppbV m/s mb & C	TECO 42 CY Dasibi & Std Met	Santa Catalina-Elevated	SoCAB

Table 5-4 (continued)
SCOS97-NARSTO Supplemental Surface Air Quality Measurements

Rec. #	Period		Averaging	Operational Checks		Calibration		Audit	
	Starting	Ending	Time	By	Period	By	Period	Performance	System
1	IOP	IOP	Hourly	CE-CERT	Daily	CE-CERT	Daily	-	-
2	IOP	IOP	Hourly	CE-CERT	Daily	CE-CERT	Daily	-	-
3	IOP	IOP	3-hrs	UCR	Measurement	UCR	Measurement	-	-
4	15-Jun-97	15-Oct-97	Hourly	SCAQMD	Daily	CE-CERT	Weekly	-	-
5	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	-	-
6	IOP	IOP	3 hrs	CE-CERT	--	CE-CERT	IOP	DRI	DRI
7	1-Sep-97	1-Oct-97	hourly	EPA	Daily	EPA	Daily	DRI	DRI
8	IOP	IOP	Continuous	PSU	Daily	PSU	Daily	?	?
9	IOP	IOP	3 hrs	UCD	IOP	UCD	IOP	-	-
10	IOP	IOP	Species Dep	UCR	Measurement	UCR	Measurement	-	-
11	IOP	IOP	3-hrs	UCR	Measurement	UCR	Measurement	-	-
12	15-Jun-97	15-Oct-97	Hourly	SCAQMD	Daily	CE-CERT	Weekly	-	-
13	15-Jun-97	15-Oct-97	Hourly	SCAQMD	Daily	CE-CERT	Weekly	-	-
14	Permanent	Permanent	Hourly	SCAQMD	Daily	SCAQMD	Daily	-	-
15	IOP	IOP	3 hrs	CE-CERT	--	CE-CERT	IOP	DRI	DRI
16	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	ARB-MLD	ARB-MLD
17	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	MLD (no NOy)	MLD (no NOy)
18	IOP	IOP	Species Dep	UCR	Measurement	UCR	Measurement	-	-
19	4 -1 week	1-Sep-97	hourly	UCLA	daily	UCLA	daily	-	-
20	IOP	IOP	3 hrs	SCAQMD	Daily	SCAQMD	Daily	-	-
21	IOP	IOP	12 hrs	UCR	IOP	UCR	IOP	-	-
22	IOP	IOP	3 hrs	CE-CERT	--	CE-CERT	IOP	DRI	DRI
23	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	ARB-MLD	ARB-MLD
24	Permanent	Permanent	Hourly	SCAQMD	Daily	SCAQMD	Daily	-	-
25	IOP	IOP	3-hrs	UCR	Measurement	UCR	Measurement	-	-
26	IOP	IOP	Hourly	CE-CERT	Daily	CE-CERT	Daily	-	-
27	15-Jun-97	15-Oct-97	Hourly	SCAQMD	Daily	CE-CERT	Weekly	-	-
28	IOP	IOP	8 hrs ??	CE-CERT	--	CE-CERT	IOP	DRI	DRI
29	IOP	IOP	Species Dep	UCR	Measurement	UCR	Measurement	-	-
30	1-Sep-97	1-Oct-97	hourly	EPA	Measurement	EPA	Measurement	-	-
31	15-Jun-97	15-Oct-97	Hourly	CE-CERT	-	CE-CERT	Weekly	-	-
32	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	ARB-MLD	ARB-MLD
33	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	MLD (no NOy)	MLD (no NOy)

Table 5-4 (continued)
SCOS97-NARSTO Supplemental Surface Air Quality Measurements

Rec. #	Institution	Investigator	Species	Units	Measurement Device	Site Location	Air Basin
34	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42CY & TECO 42	Alpine	SDAB
35	SDCAPCD	Hossain, Mahmoud	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	Black Mountain	SDAB
36	SDCAPCD	Hossain, Mahmoud	O3, NO, NOx	ppbC (ppbV)	Dasibi TECO 42	Camp Pendleton	SDAB
37	SDCAPCD	Hossain, Mahmoud	WS, WD, RH, T	m/s, C	Std Met	Camp Pendleton	SDAB
38	SDCAPCD	Hossain, Mahmoud	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	Fallbrook	SDAB
39	SDCAPCD	Hossain, Mahmoud	O3, NO, NOx, CO/ VOC, Carbonyls	ppbC (ppbV)	Dasibi TECO 42/ Cans & DNPH	Kearny Mesa	SDAB
40	SDCAPCD	Hossain, Mahmoud	WS, WD, RH, T	m/s, C	Std Met	Kearny Mesa	SDAB
41	SDCAPCD	Hossain, Mahmoud	NOy, HNO3, VOC, Carbonyls	ppbC (ppbV)	TECO 42CY/Cans & DNPH	Mount Soledad	SDAB
42	SDCAPCD	Hossain, Mahmoud	WS, WD, T, O3, NO, NOx	ppbV, m/s, C	Dasibi, TECO 42 & Std Met	Mount Soledad	SDAB
43	SDCAPCD	Hossain, Mahmoud	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	Red Mountain	SDAB
44	SDCAPCD	Hossain, Mahmoud	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	San Marcos Park	SDAB
45	SDCAPCD	Hossain, Mahmoud	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	Valley Center	SDAB
46	UC Riverside	Arey, Janet	Isoprene, Terpenes, MVK?	ppbC (ppbV)	canisters & FID	Ojai	SCCAB
47	SBCAPCD	Murphy, Tom	O3, WS, WD, T	ppbV, m/s, C	Dasibi & Std Met	Santa Rosa Island	SCCAB
48	CE-CERT	Fitz, Dennis	NOy, NO, NOx, HNO3	ppbV	TECO 42CY & TECO 42	Simi Valley	SCCAB
49	DGA	Grosjean, Daniel	PAN, PPN, PERC, Meth Chlor	ppbV	Gas Chromotagraphy-ECD	Simi Valley	SCCAB
50	DRI	Zielinska, Barbara	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	Mexicali	Mexico
51	DRI	Zielinska, Barbara	VOCs, CH4 (CO, CO2, Carbonyls)	ppbC (ppbV)	Cans & DNPH cartridge	Tijuana	Mexico
52	US Marines	Helgeson, Norm	NO NOy HNO3 NOx O3 WS WD	ppbV, m/s	DasibiTECO42CYMLab& Std Met	29 Palms	MDAB
53	DRI	Dave Shorran	Halocarbons	ppbC (ppbV)	Canisters & FID	Barstow	MDAB
54	MDAQMD/DRI	Ramirez, Bob	NO, NOy, NOx, O3, WS, WD, T	ppbV, m/s, C	Dasibi TECO42CY API & Std Met	Barstow	MDAB
55	CE-CERT	Fitz, Dennis	ozone & met	ppbV m/s mb & C	Dasibi & Std Met	Tehachepi Pass	MDAB

Table 5-4 (continued)
SCOS97-NARSTO Supplemental Surface Air Quality Measurements

Rec. #	Period		Averaging	Operational Checks		Calibration		Audit	
	Starting	Ending	Time	By	Period	By	Period	Performance	System
34	15-Jun-97	15-Oct-97	Hourly	SDCAPCD	Daily	CE-CERT	Weekly	-	-
35	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
36	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
37	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
38	Continuous	Continuous	hourly	Tetra?	Daily	Tetra?	Daily	-	-
39	Cont / IOP	Cont / IOP	hourly/3 hrs	SDCAPCD	daily/IOP	SDCAPCD	daily/IOP	-	-
40	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
41	Cont/IOP	Cont/IOP	hourly/3 hours	SDCAPCD	Daily/IOP	SDCAPCD	Daily/IOP	-	-
42	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
43	Continuous	Continuous	hourly	Tetra?	Daily	Tetra?	Daily	-	-
44	Continuous	Continuous	hourly	SDCAPCD	Daily	SDCAPCD	Daily	-	-
45	Continuous	Continuous	hourly	Tetra?	Daily	Tetra?	Daily	-	-
46	IOP	IOP	Species Dep	UCR	Measurement	UCR	Measurement	-	-
47	Continuous	Continuous	hourly	US Navy	Daily	US Navy	Daily	-	-
48	15-Jun-97	15-Oct-97	Hourly	VCAPCD	Daily	CE-CERT	Weekly	-	-
49	15-Jun-97	15-Oct-97	Hourly	DGA	Daily	DGA	Daily	-	-
50	IOP	IOP	3 hrs	Tracer ES&T	--	DRI	IOP	DRI	DRI
51	IOP	IOP	3 hrs	Tracer ES&T	--	DRI	IOP	DRI	DRI
52	Continuous	Continuous	hourly	DRI	Daily	DRI	Daily	-	-
53	15-Jun-97	15-Oct-97	hourly	DRI	Daily	DRI	Daily	-	-
54	Continuous	Continuous	hourly	DRI	Daily	DRI	Daily	-	-
55	15-Jun-97	15-Oct-97	Hourly	CE-CERT	Daily	CE-CERT	Daily	-	-

Table 5-5
Upper Air Monitoring Sites in Southern California

Site	Basin	RWP	RASS	Sodar	Radiosonde
Bakersfield	SJVAB				ARB
Goleta	SCCAB	NOAA	NOAA		
Point Mugu	SCCAB				US Navy
Port Hueneme	SCCAB	NOAA	NOAA	NOAA (mono)	
Santa Clarita Valley	SCCAB			NOAA	
Simi Valley	SCCAB	VCAPCD	VCAPCD		
Vandenberg AFB	SCCAB	USAF	USAF	NOAA	USAF
29 Palms	MDAB				US Marines
Barstow	MDAB	Radian-STI	Radian-STI		
Cajon/Hesperia	MDAB	Radian-STI	Radian-STI		
Edwards AFB	MDAB				USAF
El Centro	Salton SAB	NOAA	NOAA		
Thermal Airport	Salton SAB	Radian-STI	Radian-STI		
San Fernando Valley	SoCAB	NOAA	NOAA		CE-CERT
El Monte Airport	SoCAB	ARB	ARB		
Los Alamitos	SoCAB	NOAA	NOAA	NOAA (mono)	
Los Angeles Airport	SoCAB	SCAQMD	SCAQMD		
March AFB/Riverside	SoCAB	Radian-STI	Radian-STI		
Norton AFB	SoCAB	ARB	ARB		
Ontario Airport	SoCAB			SCAQMD	
Palmdale	SoCAB	NOAA	NOAA		
San Clemente Island	SoCAB	NOAA	NOAA		
San Gabriel Mtn	SoCAB			NOAA	
San Nicolas Island	SoCAB				US Navy
Santa Catalina	SoCAB	NOAA	NOAA		
Temecula	SoCAB	Radian-STI	Radian-STI		
Tustin	SoCAB	NOAA	NOAA		US Navy
UCLA	SoCAB				CE-CERT
USC-Hancock Fnd Bldg	SoCAB	NOAA	NOAA		CE-CERT
Alpine	SDAB	NOAA	NOAA		
Brown Field	SDAB	NOAA	NOAA		
Carlsbad	SDAB	NOAA	NOAA		
Miramar Nav Air St	SDAB				NWS
Naval Air St-North Island	SDAB				US Navy
Point Loma	SDAB				SDCPACD
Valley Center-Escondido	SDAB	SDCAPCD	SDCAPCD		

Table 5-5 provides a summary of the aloft meteorological measurements that are currently being made by local agencies and that will be made by contractor during SCOS97-NARSTO. Figure 5-5 shows the locations of the upper-air meteorological measurement sites.

Radar Wind Profilers (RWP) provide sequential horizontal and vertical wind components in data assimilation and model comparison on a sub-hour time scale. RWPs generally acquire measurements within 100 to 150 m thick layers between ~0.150 and 3 km AGL with a minimum vertical resolution of 60 meters. A radio-acoustic sounding system (RASS) are used to quantify virtual temperature to elevations of ~1 km AGL (up to 2 km AGL in ideal conditions), but this is insufficient altitude to characterize the daytime mixed layers of 2–3 km AGL often observed in much of the study area. There are currently five radar wind profilers operating in southern California, with a sixth expected near Escondido by 1997. The PAMS program requires three of the profilers. The Ventura County APCD operates one at Simi Valley, the South Coast Air Quality Management District operates one at Los Angeles International Airport, and the San Diego APCD operates one at Pt. Loma in San Diego. The other two are located at Ontario Airport and Vandenberg Air Force Base. The ARB has two profilers available to SCOS97 that will be sited within the SoCAB, as needed, e.g., at Norton AFB and at the El Monte Airport. RASS is used with each of the agency radar wind profilers to obtain a vertical profile of virtual temperature. Additional RWPs and sodars will be operated continuously during the SCOS97-NARSTO study by NOAA and Radian as shown in Table 5-5.

Acoustic Sounders (Sodars), like RWPs, also acquire continuous measurements of winds aloft. Sodars have better vertical resolution (~30 m layers from ~50 to 600 m AGL) but less vertical range (750 m AGL maximum). Sodars are most applicable in locations with lower-level structure, such as that found in marine layers, in channeling through canyons and passes, and in nighttime radiation inversions.

Radiosonde measurements provide characterization of the entire atmospheric boundary layer and portions of the upper atmosphere up to 10 mb (30 km ASL). These measurements provide information on winds, temperature, and humidity. In addition to the NWS twice-per-day (0 and 12 Z) radiosonde releases at San Diego (within the modeling domain) and at Desert Rock, Nevada (on the east side of the northern border of the modeling domain), several military organizations in southern California release radiosondes, including the Naval Air Warfare Center (NAWC) which also takes regular ozonesonde data at Point Mugu (and occasionally at other selected sites in Ventura County). The frequency of radiosonde NAWC releases at San Nicolas Island and Pt. Mugu will be increased from twice-per-day to four times per day during IOPs as part of SCOS97. Radiosonde launches are also made periodically at Vandenberg AFB, Edwards AFB, Miramar NAS, and China Lake NAS, but these facilities launch on their own schedules. Also, the SCOS97 effort will provide radiosonde packages to two other military installations which can arrange to schedule twice-per-day (0 and 12 Z) radiosonde releases during IOPs in addition to their own launches. Of the four military installations, Vandenberg and Edwards AFB are the most likely candidates. Four additional radiosonde sites, with four releases per day during IOPs, will be provided as part of the SCOS97 effort.

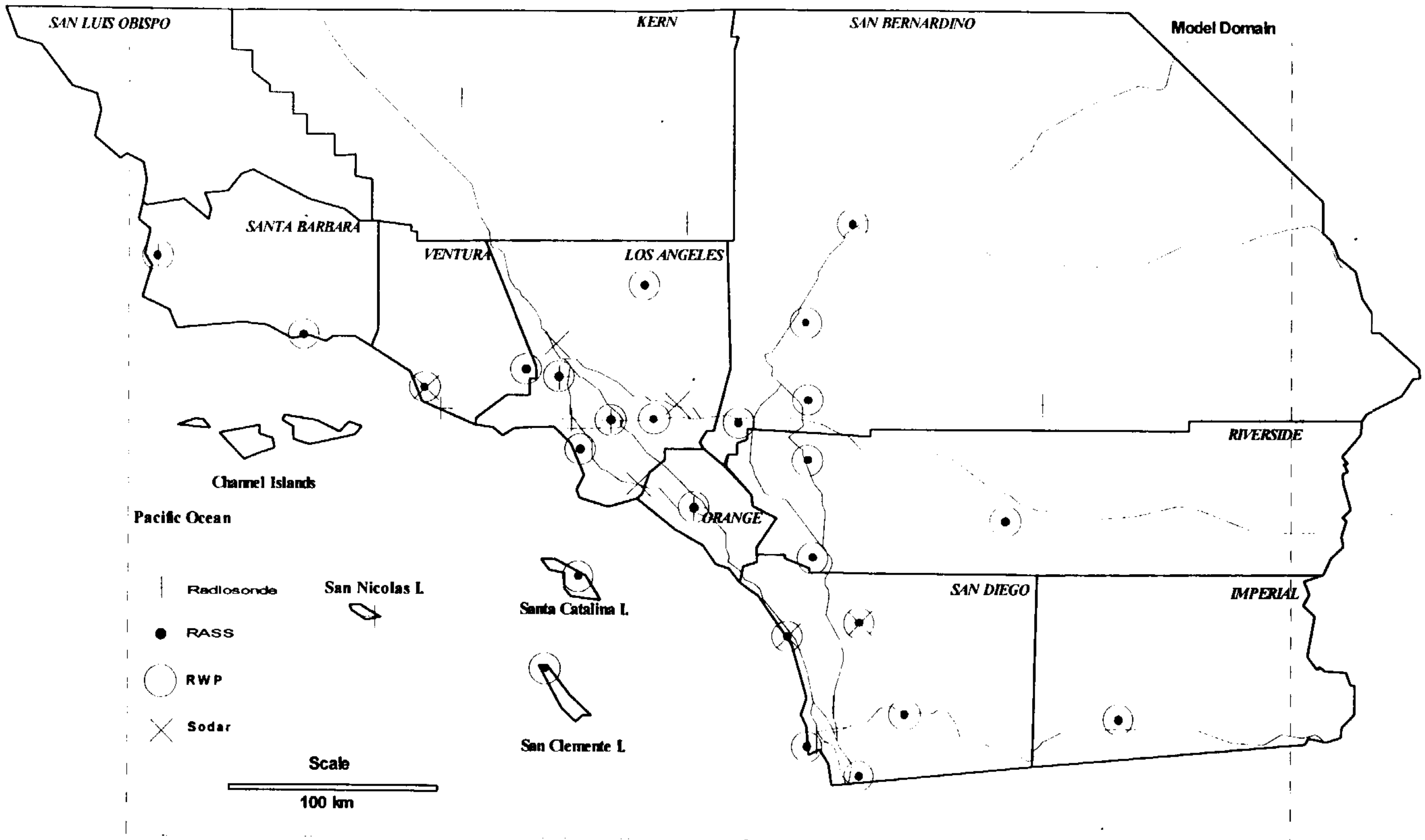

Figure 5-5. Upper-air meteorological measurement locations for SCOS97-NARSTO.

5.4.4 Aloft Air Quality Measurements

Aloft air quality measurements will be made during IOPs using instrumented aircraft and ground-based lidar and ozonesondes. These measurements will be used to measure the three dimensional distribution of ozone, ozone precursors, and meteorological variables. The aircraft will provide information at the boundaries and will document the vertical gradients, the mixed layer depth, and nature of elevated pollutant layers. The concentrations and (in conjunction with upper air wind soundings) the transport of pollutants across selected vertical planes will be measured to document transport of pollutants and precursors between offshore and onshore and between air basins. Redundancy and operational cross-checks can be built into the aircraft measurements by including overlapping flight plans for the various types of aircraft and by doing aircraft measurements near the ground over air quality monitoring sites. Table 5-6 provides a summary of the aloft air quality measurements that will be made by contractors. Table 5-6 also indicates planned systems and performance audits.

The NOAA ground-based lidar will be used to characterize the vertical ozone structure within the SoCAB. This lidar could be located at El Monte within the San Gabriel Valley to examine the bifurcation of flow from Los Angeles to the San Fernando and San Gabriel Valleys. Ozonesondes will be released at the ground-based lidar sites for quality assurance purposes and to obtain a higher vertical range of ozone distributions. Four ozonesondes will be released at six different sites each day of an IOP. Collocation with the ozone lidars dictates that two of the six ozonesonde sites would be at El Monte and Ontario. El Monte has surface ozone but Ontario does not. However, Upland has a surface ozone monitor and is not too distant from Ontario. Four other recommended locations are at Van Nuys Airport to characterize San Fernando Valley vertical ozone structure for possible transport to Ventura, Anaheim in the south basin for possible transport from the south coastal plain of the SoCAB to San Diego, and Temecula for inland transport to San Diego. Central Los Angeles is also desirable to characterize the central SoCAB, but logistics in the downtown area may be a complicating factor. Data will also be available from the existing NAWC ozonesonde release site at Pt. Mugu.

Six aircraft are included in the SCOS97-NARSTO field measurement program. The objectives and specific flight plans are being developed for these aircrafts under different meteorological scenarios by staff of the ARB Research Division and the SCOS97 Modeling Working Group. The following objectives are proposed for each aircraft.

<u>UCD Cessna 182</u>

The objectives for this aircraft are 1) to collect pertinent data for validating ozone measurements by lidar (NOAA at El Monte Airport) 2) to collect data pertinent to characterizing processes resulting in ozone layers aloft in SoCAB; and 3) to collect data pertinent to characterizing ozone fluxes in San Fernando Valley.

Table 5-6
SCOS97-NARSTO Aloft Air Quality Measurements

Rec. #	Institution	Investigator	Species	Units	Range	Device	Location	Air Basin
1	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	Cal State Northridge	SoCAB
2	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	USC-Hancock Fnd Bldg	SoCAB
3	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	Anaheim	SoCAB
4	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	North San Diego County	SDAB
5	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	Riverside	SoCAB
6	CE-CERT	Fitz, Dennis	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde - KI	Upland	SoCAB
7	CE-CERT/STI	Fitz, Dennis	VOCs, CH_4 (CO, CO_2, Carbonyls)	ppbC (ppbV)	-	Cans & DNPH cartridge	Northern Boundary	Various
8	CE-CERT/UCD	Fitz, Dennis	VOCs, CH_4 (CO, CO_2, Carbonyls)	ppbC (ppbV)	-	Cans & DNPH cartridge	In SoCAB	SoCAB
9	NOAA	Zhao, Yan	ozone	ppbV	Srfc to 1 Km/100m	Lidar	El Monte Airport	SoCAB
10	US Navy	Helvy, Roger	ozone	ppbV	Srfc to 5 Km/100m	Ozonesonde	Point Mugu	SCCAB
11	US Navy	Helvy, Roger	ozone & met	ppbV m/s mb & C	Srfc to 1 Km/100m	Dasibi & Std Met	Point Mugu	SCCAB
12	EOPACE	Jensen, Doug	ozone, NO, NO_y, met	ppbV m/s mb & C	Srfc to 1 Km/100m	Dasibi, TECO 42 CY, std Met	Montgomery Field	SDAB
13	SDCAPCD	Bigler-Engler, Virginia	ozone, NO, NO_2, met	ppbV m/s mb & C	Srfc to 1 Km/100m	Dasibi, Monitor, std Met	Montgomery Field	SDAB
14	STI	Blumenthal, Don	ozone, NO, NO_y, met	ppbV m/s mb & C	Srfc to 1 Km/100m	Dasibi, TECO 42 CY, std Met	Camarillo Airport	SCCAB
15	UC Davis	Carroll, John	ozone, NO, NO_y, met	ppbV m/s mb & C	Srfc to 1 Km/100m	Dasibi, TECO 42 CY, std Met	El Monte Airport	SoCAB

Table 5-6 Continued
SCOS97-NARSTO Aloft Air Quality Measurements

Rec. #	Flight Plan	Period		Averaging	Operational Checks		Calibration		Audit	
		Starting	Ending	Time	By	Period	By	Period	Performance	System
1		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
2		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
3		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
4		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
5		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
6		IOP	IOP	seconds	CE-CERT	launch	CE-CERT	launch	-	-
7	Various	IOP	IOP	Minutes	CE-CERT	--	CE-CERT	IOP	DRI	DRI
8	Various	IOP	IOP	Minutes	CE-CERT	--	CE-CERT	IOP	DRI	DRI
9		IOP	IOP	seconds	NOAA	Daily	NOAA	Daily	Airplane-UCD	-
10		IOP	IOP	seconds	US Navy	launch	US Navy	launch	-	-
11	• 2 flights/day-north 1/2 southern boundary	15-Jun-97	15-Oct-97	Hourly	U.S. Navy	Flight	U.S. Navy	Flight	-	-
12	• 2 flights/day - saw tooth/southern boundary	IOP	IOP	seconds	EOPACE	Flight	EOPACE	Flight	Airplane-UCD	ARB-MLD
13	• transport SoCAB-SDAB-Eastern Boundary	IOP	IOP	seconds	SDCAPCD	Flight	SDCAPCD	Flight	Airplane-UCD	ARB-MLD
14	• 2 flights/day - saw tooth/northern boundary	IOP	IOP	seconds	STI	Flight	STI	Flight	Airplane-UCD	ARB-MLD
15	• 3 - 4 flights/day - 3 spirals/flight San Gabriel	IOP	IOP	seconds	UC Davis	Flight	UC Davis	Flight	MLD-Lidar	ARB-MLD

STI Piper Aztec

Objectives of this aircraft are: 1) to provide boundary and initial conditions in northern portion of study domain; 2) to serve as back-up to the western boundary (over ocean) aircraft; 3) to collect data pertinent to characterizing ozone and NOy fluxes near passes; and 4) to collect data pertinent to characterizing ozone and NOy in SoCAB.

San Diego –EOPACE Navajo

The objectives of this aircraft are: 1) to provide boundary and initial conditions in the western region of the modeling domain; 2) to collect data on any offshore movement (e.g., land-sea breeze circulation cell, Santa Ana) of pollutants from SoCAB. This aircraft will be based at Montgomery Field in San Diego. Conflict with EOPACE operations during Aug 25 – Sept 12 is the main operational constraints.

Gibbs Cessna 182

The objectives of this aircraft are: 1) to collect onshore measurements to determine the presence of pollution transport between SoCAB and SDAB; 2) to collect data on initial conditions in the southern portion of the modeling domain.

Pt. Mugu NAWC Aircraft

The objectives of this aircraft are: 1) to collect pertinent data for documenting the spatial distribution of polluted layers (ozone and aerosols) offshore of Santa Monica Bay and onshore in vicinity of Pt. Dume and Laguna Peak.

Pelican Aircraft

The objectives of this aircraft are: 1) to collect pertinent data for documenting the spatial distribution and the temporal evolution of aerosols aloft in the SoCAB; 2) to collect ozone data aloft which will supplement the other measurements by lidar, sondes, and other aircraft.

6. QUALITY ASSURANCE

The primary purpose of the quality assurance (QA) tasks is to provide a quantitative estimate of the uncertainty of the measurements through estimates of the precision, accuracy (or bias), and validity. In addition, QA ensures that the procedures and sampling methods used in the study are well documented and are capable of producing data which meet the specifications of the study. Quality assurance is intimately connected with data management. Before sampling starts, the QA team assists the investigators and the data management contractor to develop the format of the database; the QA team also reviews the investigators' standard operating procedures (SOPs) and makes estimates of the precision and accuracy that might be expected from the measurement systems. Prior to or during sampling the QA team carries out quality audits and helps resolve any problems.

The quality assurance program includes two types of activities: quality control (QC), and quality auditing (QA). The QC activities are on-going activities of the measurement and data processing personnel. QC activities consist of written standard operating procedures to be followed during sample collection, sample analysis, and data processing. These procedures define schedules for periodic calibrations and performance tests (including blank and replicate analyses). They specify pre-defined tolerances which are not to be exceeded by performance tests and the actions to be taken when they are exceeded. The QC activities also include equipment maintenance, and acceptance testing, and operator training, supervision, and support.

Quality auditing consists of two components: systems audits and performance audits. Systems audits include a review of the operational and quality control (QC) procedures to assess whether they are adequate to assure valid data which meet the specified level of accuracy and precision. After reviewing the procedures, the auditor examines phases of the measurement or data processing activity to determine whether the procedures are being followed and that the operating personnel are properly trained. The system audit is a cooperative assessment resulting in improved data. Performance audits establish whether the predetermined specifications for accuracy are being achieved in practice. For measurements, the performance audit involves challenging the measurement/analysis system with a known standard sample that is traceable to a primary standard. Performance audits of data processing involve independently processing samples of raw data and comparing the results with reports generated by routine data processing. The specialized nature of some measurements (e.g., hydrocarbon speciation, carbonyl compounds, PAN, NO_y, ozone lidar, upper air meteorology) preclude simple performance audits for these measurements. Intercomparison studies are typically used to assess the representativeness, accuracy, and precision of these measurements.

6.1 Quality Assurance Team

Quality assurance will be under the overall direction of the QA manager who will coordinate a QA team. The team will consist of the QA manager and sponsoring agencies that have the necessary expertise. The QA manager and team will be responsible for developing a QA plan for the study, reviewing standard operating procedures, performing systems and performance audits, reviewing and validating study data processing procedures and data, and estimating the uncertainties in the data. The QA team will work closely with the data manager, the field manager, and investigators. The QA manager should be selected early and should be an integral member of the planning team. The QA manager should coordinate with and be assisted by the audit staff members of the air quality agencies in the study area to assure that measurements are based on the same standards.

Once the sampling has been completed and the investigators have provided the data management contractor with a clean data set, the QA team helps validate the data in two stages, Level 1 (univariate checks such as maxima and minima, rates of change, and diurnal variations) and Level 2 (multivariate consistency tests based on known physical, spatial, or temporal relationships). The QA team also makes the final estimates of the precision and accuracy of the data with the help of the investigators and the data manager.

Quality auditing tasks can be performed both by contractors and by the QA staff of the sponsoring organizations. The QA manager bears overall responsibility for ensuring that the quality auditing tasks are performed by members of the QA team. The major tasks are summarized below.

Overall:

- Manage the overall QA activities. Interact with the field manager and the principal investigator and provide feedback to them concerning the status of unresolved QA problems and the potential for their resolution.

Before field operations begin:

- Work with investigators to determine whether each measurement method is likely to meet its specifications for accuracy (or bias) and precision.

- Review the SOPs for each measurement and verify the assumptions on which they are based.

- Prepare systems audit procedures.

- Perform preliminary systems audits at investigators' analytical laboratories, paying particular attention to calibration methods.

- Develop performance audit procedures for measurements for either accuracy (i.e., compared to established standards) or, where that is not possible, for bias (i.e., compared to another co-equal laboratory's measurements).

- Arrange for investigators' calibration standards to be checked against EPA, ARB or other standards.

- Audit transfer standards.

- If not all field sites are to be audited, develop a priority system indicating which field sites and which laboratories should be audited during or just prior to field measurements.

- Immediately prior to field operations, carry out performance audits of the continuous gas analyzers and flow measuring instruments at the chosen field sites.

During field operations:

- Perform systems audits on field and laboratory measurements and data processing procedures. Field air quality measurement sites, sampling aircraft, upper air sites, and meteorology sites should be audited.

- Perform systems audits for the data processing and data management operations of the measurement and data management contractors.

- Coordinate performance audits on routine measurements. Arrange for or perform those audits not done by the sponsoring organizations.

After field operations:

- Prepare reports of the audits.

- Work interactively with the data management contractor in the on-going Level 1 and Level 2 validation of the data.

- Work with investigators to determine the accuracy (or bias) and precision for each measurement value and prepare a report summarizing the uncertainties in the study data.

A quality assurance plan specifies the activities associated with the SCOS97 quality assurance program, schedules, and responsibilities. The following sections describe elements of the Quality Assurance Plan.

6.2 Quality Assurance Objectives for Measurement Data

Data quality objectives should be specified prior to the study to ensure that all measured data meet the end-use requirements for air quality and meteorological model input and evaluation, data analyses, and monitoring the success of meeting data quality objectives. Precision and accuracy goals are identified for measurement variables. Many methods and procedures employed in SCOS97 are routinely measured variables for which expected precision and accuracy are known. Other measurements are experimental and target objectives can only be estimated.

In evaluating precision and accuracy objectives, it is important to consider the methods used to determine the values. For example, a greater deviation may occur between replicates with real samples with complex matrices than with replicates of standards in simple matrices. Synthetic mixtures of hydrocarbons that are used in the Photochemical Assessment Monitoring Station Program is an example. An ambient sample yields a more complex chromatogram and greater potential for inconsistent identification. Analysis of a standard mixture of hydrazones does not address potential sampling artifacts that may be associated with carbonyl compound measurements using the DNPH derivitization method.

Precision and accuracy targets are commonly based on relative percent differences. Precision is either based on a relative percent difference between replicates (analytical precision) or duplicate samples (method precision) as follows:

$$100 * (rep1 - rep2)/(rep1 + rep2)/2$$

The standard deviation of the average of a group of replicate (or duplicate) pairs represents the precision for a measurement parameter. For accuracy, percent difference is determined relative to a known or target value and is as follows:

$$100 * (observed - target)/target$$

The objective may be a standard of known concentration or an audit value independently obtained or prepared by the QA team. For some parameters, standards of known concentration are not easily obtained or cannot be accurately prepared for use in the field, and accuracy can only be checked against an independent method that is believed to be either without bias, has a known bias that can be accounted for, or a method that has been used historically. Accuracy determined in this manner is considered a test of equivalency and not true accuracy.

After an audit, data flags are reported immediately to the field operations manager and to the appropriate contractor to ensure rapid implementation of corrective action by the measurement group.

6.3 Systems Audits

6.3.1 Field Systems Audits for Surface Monitoring Sites

Prior to the start of the field study, the auditing team obtains pertinent forms and documents, their latest revisions, and information needed to perform the audits. These forms and documents include SOPs, instrument manuals, logbooks, chain-of-custody records, data sheets, control charts, and maintenance records. The auditor verifies that each of these forms and documents is available at the field site. If out-of-date documents are identified at the field site, recommendations for replacement are made in the systems audit report. Calibration records, performance test tracking charts, and maintenance records are examined to determine that the tasks were being performed on the schedules specified in the SOP. Contents of logbooks and checklists are examined to determine that the field documentation procedures were being followed. The auditor examines the site description, field documentation, SOPs, spare parts, and supplies, and performs a general instrument inspection. The QA manager coordinates review of the latest revision of field SOPs and ensures that each auditor has the most recent version prior to systems audits. The auditor independently evaluates the siting of measurement platforms to document relevant characteristics that might affect the measurement at a particular location. An inspection of measurement devices and evaluation of their condition with respect to obtaining a quantitative measurement is also part of each system audit. The audit examines the relationship among different instruments and their conformity with requirements at each site. The instrument serial numbers and model numbers are compared with those recorded in the project records as being present at each site. Sample lines are examined for dirt or obstruction. Leads from each instrument to data acquisition system are examined to ensure that they are connected to the proper channels. Inconsistencies with project records are reported, and recommendations for site modification are made by the QA manager.

6.3.2 Field Systems Audits for Aircraft Platforms

Aircraft systems audits are similar to surface systems audits. A systems audit questionnaire is completed by the auditor for each aircraft. The auditor reviews the type of measurements that are actually being performed relative to those specified in the most recent work plan. The level of documentation of quality control checks, instrument logs, etc., are examined. Results of calibration records and performance tests are evaluated. The auditor records pertinent information relative to the sampling system to form an independent documentation of conditions as they existed during the audit.

6.3.3 Laboratory Systems Audits

Laboratory analysis and data processing activities are audited in this procedure. The laboratory systems audit examines the procurement and acceptance testing of sampling substrates, laboratory documentation, SOPs, laboratory instrumentation, spare parts, and supplies. A traceability audit randomly selects a single data value for each observable from a recent data report and tracks the documentation and traceability to standards associated with that value. This traceability audit determines how well each of the individual procedures was integrated to produce valid data values.

6.4 Performance Audits

6.4.1 Field Performance Audits of Surface Monitors

Quantitative transfer standards are used during field performance audits to determine the percent difference between the field measurements and the standard (i.e., to estimate the accuracy of the measurement). The difference should meet the acceptance criteria defined by the quality assurance objectives. Otherwise, reasons for exceeding acceptable levels are sought, and recommendations are made for eliminating the problem and adjusting or flagging data as necessary.

Ozone. A calibrated transfer standard with an internal ozone generator is used to generate five standard ozone concentrations and one zero level concentration to audit the instruments. Corresponding concentrations are recorded from each instrument and compared. A linear regression of measured versus audit results is calculated to determine baseline offsets and linearity of response. The in-station performance test gases are verified against the certified NIST standards. The audit includes a comparison of values taken from the instrument display, the strip chart recorder, and the data acquisition system.

Standard and High-sensitivity NO/NO_X. A calibrated audit system used to challenge the standard sensitivity instruments consists of zero air, NIST-traceable NO gas in a cylinder, and an ozone generator. At least three NO concentrations and a zero are introduced to the instrument, and the response of the data acquisition system and the instrument are recorded. Audit NO_2 is produced by gas-phase titration and introduced to the analyzer for at least five different concentrations. Audit versus site differences are determined, and a linear regression of site versus audit results is calculated to determine baseline offsets and linearity of response. In addition, site test gases are verified against the audit standard.

High-sensitivity NO_2. This audit involves the use of a calibrated audit system consisting of zero air and a NIST-traceable low concentration NO_2 gas cylinder. These standards can be unstable with time, and precautions need to taken into account for any degradation that occurs during the audit process. At least three NO_2 concentrations and a zero are introduced to the instrument, and the response of the data acquisition system and the instrument is recorded. Audit versus site differences are determined, and a linear regression of site versus audit results is calculated to determine baseline offsets and linearity of response. In addition, site test gases are verified against the audit standard.

PAN. Since NIST transfer standards do not exist for PAN, collocated measurements using a gas chromatograph with electron capture detection (GC/ECD) may be used for comparison. PAN is thermally unstable, even at room temperature, and thus difficult to calibrate. This difficulty can lead to discrepancies between field measurements that are difficult to resolve without further laboratory studies. One advantage of the LPA-4 PAN analyzer is that the instrument can be calibrated in the field with NO_2 rather than the thermally unstable PAN (see Section 3.4.2 for additional details). Level 2 validation of the PAN data includes correlation and time series of PAN values compared to NO_y, NO_z, and NO/NO_2 ratios.

6.4.2 Field Performance Audits for Surface Meteorological Measurements

This audit includes the variables of wind direction, wind speed, temperature, relative humidity, and solar radiation. These procedures generally are performed by both auditor and site operator, since several of these procedures require readings to be made in the instrument shelter while someone is on the meteorological tower. Safety considerations also require the presence of an additional person whenever someone ascends the tower. Audit values are compared with instrument displays (when available), stripchart output, and data acquisition system output. In this way, the entire measurement system is audited, and the causes of exceedances of the acceptance criteria can be isolated. The following paragraphs summarize the audit procedures.

Wind Direction. Distance sighting targets are determined for each site. Where possible, these targets are measured with a stable sighting compass on a nonmagnetic tripod and corrected for declination. The operator ascends or cranks down the tower and aligns the point and tail of the wind vane toward these targets while the auditor records the output in the shelter. Differences between true and measured direction are recorded. Vane starting thresholds are checked using a starting torque watch.

Wind Speed. The anemometer cups are temporarily replaced by synchronous motors, and the equivalent wind speed displayed by the anemometer is compared with the speed corresponding to the rotation rate as supplied by the manufacturer. Anemometer starting thresholds are checked from a torque measurement using a gram scale applied at a measured distance from the axis of rotation.

Temperature. An aspirated thermometer traceable to standards from the NIST is placed adjacent to each temperature-sensing device, and the two readings are compared. The resistance of temperature-sensing units is compared to the NIST-traceable thermometer. When feasible, two sets of readings are taken to cover a wide range of readings.

Relative Humidity. An aspirated psychrometer using NIST-traceable thermometers is operated at the level of the relative humidity sensor. Relative humidity based on the psychrometer readings is determined and compared to the instrument value.

Solar Radiation. An audit pyranometer is zeroed and readings are taken with the audit instrument placed next to the station pyranometer. A comparison is made between the hourly average readings of the two instruments.

6.4.3 Field Performance Audits for Upper-Air Meteorology

Field audits for upper-air meteorological measurements form surface-based platforms are particularly challenging, and special techniques are needed. For systems, ground truthing of set-up conditions (surface wind, pressure, and temperature) is performed similar to the standard surface meteorology audit procedures described above. In addition, for Doppler acoustic sounders and radar profilers, performance audits are accomplished using collocated audit tethersondes, radiosondes, and/or instrumented aircraft (flying nearby spirals). The Quality Assurance Plan for SCOS97 will need to provide more specific quality assessment and data validation procedures.

6.4.4 Field Performance Audits for Aircraft Platforms

Quantitative transfer standards, similar to those used for the performance audits of the surface-based monitors, are used to challenge each measurement system aboard the aircraft platform. Results of each audit are compared to acceptance criteria and values that exceed the criteria are flagged. Immediately following the audit, the auditors provide a verbal report of the audit to the appropriate aircraft supervisor. During the verbal report, values and equipment problems are discussed in terms of possible reasons for the discrepancies and corrective action to be taken. If corrective action is implemented, the audit is repeated.

6.4.5 Laboratory Performance Audits for Chemical Analysis

Laboratory performance audits for SCOS97 will consist of the submission of blind performance evaluation samples of known concentrations and/or interlaboratory comparisons of samples for measurements of individual and total hydrocarbons and carbonyl compounds.

Experiences from previous field studies demonstrate that measurements of ambient hydrocarbon speciation are not routine, and that the quality and completeness of measurements vary among different laboratories using essentially the same samplers and analytical instrumentation (Fujita *et al.*, 1994). Potential problems include: positive and negative artifacts due to effects of sampler and sampling media; incomplete resolution or loss of C_2-C_3 hydrocarbons due to introduction of excessive moisture in the column or improper sample loading and injection; underreporting of true concentrations due to selection of incorrect integration threshold; loss of material in the analytical system due to poor chromatographic technique (particularly for very light and heavy hydrocarbons) or prolonged storage in canisters prior to analysis (especially for olefins and some aromatics); incorrect or incomplete peak identification due to limitation of peak identification software, especially for compounds that exist in lower concentrations and elute in a crowded segment of the chromatogram; systematic bias due to calibration problems; and variable measurement of true total NMHC among laboratories due to variation in analytical method and data processing (e.g., use of Nafion® dryer, inclusion or exclusion of oxygenated compounds in total NMHC). Interlaboratory comparisons using ambient samples are required to fully assess these problems. Also the need to measure VOC species that are not currently quantified in the PAMS program (semi-volatile hydrocarbons and oxygenated compounds) should be evaluated with respect to the goals of SCOS97. For example, MTBE is a major component of ambient VOC in areas where this compound is the primary oxygenated compound in reformulated gasoline (RFG) and higher molecular weight carbonyls are relatively more abundant in downwind receptor areas. MTBE may serve as a useful marker for motor vehicle emissions and higher carbonyls have important implications for photochemical modeling.

The sampling and analytical parameters that affect the accuracy and validity of measurements of carbonyl compounds by the 2,4-dinitrophenylhydrazine-impregnated cartridge technique (TO-11) are not completely resolved and are currently under extensive study and scrutiny by EPA and the scientific community (NARSTO-NE: field comparison in Agawam, MA, SOS: formaldehyde intercomparison at Boulder, CO, field measurement comparison in Nashville, TN). Relevant parameters include the substrate (type, DNPH loadings, blank levels, and variability), sampling conditions (ambient ozone concentrations, temperature, relative humidity, sample volume measurements, breakthrough, type of sampling line and ozone scrubber), sample storage, and handling (exposure to light and heat, type of storage and duration of storage), sample preparation and analysis (extraction efficiency and instrument calibration, peak resolution).

Each of the air pollution control districts (APCD) in southern California that have PAMS networks (Ventura County APCD, South Coast Air Quality Management District, and San Diego APCD) participate in performance audit programs run by the EPA and by the California Air Resources Board. Both the federal and state performance audits for hydrocarbons involve analysis of a standard mixtures of target compounds on an annual basis during the PAMS measurement season. Carbonyl audits involve laboratory analysis of standard extracts of selected hydrazones. While these audits can document possible systematic calibration biases, they do not address a number of other potential problems that can affect the accuracy of analytical results.

The following quality assessment tasks should be completed prior to the SCOS97 field study in order to resolve these issues.

- The ARB should conduct expanded performance audits of the district hydrocarbon measurements during the summer of 1996. In addition to the synthetic audit mixtures, the expanded performance audit should also include a set of ambient samples consisting of both urban, mobile source dominated samples and downwind, aged air samples. In addition to the ARB laboratory, one other laboratory (possibly EPA-AREAL) should participate in the interlaboratory comparison. A similar interlaboratory comparison should be conducted in 1997 prior to the SCOS97 IOPs. This comparison should include the contractor that is selected to provide supplemental VOC measurements.

- Review and summarize the results of past EPA and ARB performance audits of the PAMS programs in southern California. Summarize the problems that were identified and corrective actions that have been taken.

- Review the results of on-going hydrocarbon interlaboratory and performance audit programs in other regions of the country. For example, DRI is currently coordinating a performance audit of the PAMS networks in the northeastern U.S. as part of the NARSTO-NE project. What are the implications for the PAMS program in southern California.

- Review recently completed and on-going laboratory evaluations and intercomparisons for carbonyl measurements by Method TO-11.

- Incorporate these tasks in the quality assurance plan for SCOS97 and include results in the final QA report for the SCOS97 field measurement program.

6.4.6 Lidar QA Procedures

In situ measurements should be taken at the same time and spatial location as some of the lidar measurements. One part of the resulting in situ data should be given to the group operating the lidar system for improving and fine tuning their data analysis algorithms. Another part of the in situ measurements should be held back for QA purposes. This final QA should take place after the analysis of the lidar data is completed. Several different sources of in situ measurements should be utilized:

- Lidar co-located with an air quality monitoring station with surface ozone measurements and intermittent ozonesondes. These measurements serve as near point for the lidar intercomparison.

- Depending on the local topography, in situ ground-based instruments could be located on a rooftop or hillside in the immediate vicinity of a lidar beam path used as part of its scanning pattern. Intercomparisons would be performed at fixed ranges.

- The QA aircraft flies a spiral above the ground based lidar. Intercomparison for a vertical profile and/or intercomparison for different parts of the scanning pattern. Depending on the scanning pattern, different flight paths besides spirals might be useful.

Fujita et al., 1994, 6-8

7. COMMUNICATIONS, DATA MANAGEMENT AND DATA VALIDATION

Data used for data analysis and modeling in SCOS97 derive from measurements made as part of the study as well as from other sources. The execution of the technical study plan will involve several investigators at different locations, each providing validated measurements that are integrated with those from the others. Measurements from other databases will be requested, received, transformed into common units, and reformatted for compatibility with data acquired during the field study. Common communications, data management, and validation conventions are needed to allow this information to be gathered and disseminated in an efficient manner. These conventions are described in this section.

7.1 Internet Server

SCOS97 data and communications and will be received and made available on the Internet server "scos97.arb.ca.gov." The server is a UNIX– or Windows NT–based computer located at the ARB office in Sacramento, CA. It has the following characteristics: 1) a T1 or faster telecommunications line; 2) at least two 28.8K baud dial-up modems with dedicated phone lines; 3) at least 25 Gbyte of disk space; 4) high density EXOBYTE tape drive; 5) CD-ROM reader and writer; 6) internal network connections to ARB workstations and personal computers.

Authorized project participants are issued identification codes by the data manager, and they select their own password to have access to the project files. The server can be accessed through the Internet by those who have Internet connections and by dial-up. All Internet functions (Hahn and Stout, 1994) are supported, including: 1) "telnet," which allows use of the server from remote sites, 2) "ftp" file transfer protocol, which allows the rapid transfer of data files between the user and the server; 3) "e-mail" electronic mail, which allows project participants to communicate with each other; 4) "finger" participant locator, which provides basic information (e.g., name, affiliation, address, phone number, fax number, e-mail address, etc.) for each project participant; and 5) world wide web, which provides a home page via which project participants may navigate through the files related to the project.

Current project participants are identified by the alias "scosgr" and mail and announcements can be distributed to all participants by addressing it to "scosgr@scos97.arb.ca.gov." Other aliases are created for smaller communications groups as needed by the project. Basic instructions for Internet operation and data access are included in a README file in the SCOS97 root directory and in a link to the SCOS97 home page.

7.2 Directory Structure

Data and communications files are organized into several sub-directories within the SCOS97 server. Each of these contains additional sub-directories to further organize the information. All directories, with exception of the TEMP directory, have read-only privileges for most users to avoid the inadvertent erasure of information. Files may be uploaded to the TEMP directory for later placement in the appropriate read-only directory by the data manager. These SCOS97 directories are:

- TEMP: This is a temporary location where files are uploaded by project participants prior to their transfer to their designated parent directory. An e-mail message should be sent to the data manager indicating the uploaded file name and its desired directory location. The TEMP directory is also used to allow the transfer of non-archived scratch files among project participants.

- REPORTS: This directory contains files related to project reports, memoranda, and minutes. Sub-directories are:

  -- PROGPLN for the latest draft of the program and management plans
  -- MEMO for project memoranda
  -- MINUTES for minutes of discussions
  -- PRGREP for progress reports
  -- RFP for final versions of requests for proposals

- DATA: This directory contains data files in the form they are received from the data source. These files are in several different formats, cover different time periods, and do not necessarily conform to the units and variable naming conventions adopted for SCOS97. To conserve disk space, these files are usually backed up onto storage media after they have been processed; they can be re-loaded upon request to the data manager. They are located in directories specific to each data supplier, as specified in the next section.

- DBASE: This directory contains validated ambient measurement data in xBase (*.DBF) formats that have been converted to common units and variable names. These conventions are described below. These files are organized according to their source:

  -- MISC for database documentation files described below
  -- AI for data from the AIRS database
  -- AR for data from the Air Resources Board
  -- BL for data from the Bureau of Land Management
  -- FS for data from the U.S. Forest Service
  -- NO for data from the National Oceanic and Atmospheric Administration
  -- NW for data from the National Weather Service
  -- RA for data the Remote Automated Weather Station (RAWS) network
  -- MM for data from the Minerals Management Service
  -- SQ for data from the South Coast Air Quality Management District

- QA: This directory contains quality assurance results from audits, performance tests, and collocated measurements.

- TABLES: This directory contains tables of processed results, including statistical summaries of data, frequency distributions, and data capture rates. These are made available via html links through the SCOS97 home page.

- FIGURES: This directory contains figures of processed results, including time series, spatial isopleth plots, cumulative frequency plots, and scatterplot comparisons. These are made available via html links through the SCOS97 home page.

- MAPS: This directory contains base maps of terrain, highways, population centers, political boundaries, land use, and surface characteristics in formats that are deemed useful for different analyses.

- UTILITIES: This directory contains software created for the project, software available for distribution for which licenses have been obtained, and commonly used shareware. These include data conversion, format conversion, file compression, and data display programs. These are made available via html links through the SCOS97 home page.

Other directories and sub-directories are created as needed to organize the information produced by SCOS97.

7.3 File Extensions

Several data files are binary and can be accessed only by specific software packages. The type of file is specified by its three-character extension. Table 7-1 shows the extensions associated with different software packages. Since additional extensions will be added during SCOS97, the SCEXT.DBF file in the DBASE\MISC directory can be consulted for a current list of extensions in use.

7.4 Data Formats, Conventions and Structure

Numerical values acquired by field measurement methods are stored in xBase (*.DBF) data formats. This format, though somewhat dated, is almost universally accessible by most commonly used software packages and an infrastructure for handling data in this form has already been established in the ARB's Technical Services Division. Programs for input, merging, calculations, unit conversions, validation, and output that were created for SARMAP and the California Regional Particulate Air Quality Study can be adapted to SCOS97. Regardless of the data file formats, several conventions must be established that will be the same for all data in the numerical database.

7.4.1 Database Documentation

The \dbase\misc directory contains the following informational files that document the numerical database:

Table 7-1
Filename Extensions and Definitions

.BNA	MapViewer boundary file (ASCII)
.BND	MapViewer boundary file (binary)
.CSV	ASCII data file with comma-separated values
.DAT	MapViewer data file
.DBF	xBase (i.e., dBase, FoxPro) database file
.DBT	dBase memo field file
.DOC	Microsoft Word document
.FPT	FoxPro memo field file
.MAP	MapViewer map file
.PRG	dBase or FoxPro program file
.TXT	ASCII text file
.VOY	VOYAGER file
.WK1	LOTUS 123 spreadsheet file
.WP5	Wordperfect 5.0, 5.1, or 5.2
.XLC	Microsoft Excel chart file
.XLM	Microsoft Excel macro file
.XLS	Microsoft Excel spreadsheet file
.XLT	Microsoft Excel template file
.ZIP	File or set of files compressed with PKZIP. Uncompress with PKUNZIP.

- SCFLDNAM.DBF: This file contains variable names, units, field lengths, and decimal positions (precision) for each variable in every other file. All variables of a given type have been converted to common units, regardless of their original units, and these units are specified in this file. For example, National Weather Service wind speeds included in the database are in meters/second, even though they were obtained from NWS in knots. Table A-1 in Appendix A, modified from the SARMAP ozone study, provides a starting point for the SCFLDNAM file.

- SCSITE.DBF: This file contains monitoring site codes, site names, coordinates (in latitude and longitude and UTM Zone 10), elevations in meters above mean sea level, and the types of measurements acquired at each site. A data quality designation is provided for sites that are operated by other agencies, such as the Remote Automated Weather Station (RAWS) monitoring network. This designation is drawn from each agency's data documentation to facilitate the selection of sites for use in data analysis and modeling. Subsequent fields identify the types of measurements available at each sampling site; these are defined in SCFLDNAM.DBF.

- SCFILES.DBF: This file lists file names, their location (i.e. directory path), and date of latest update. This file should be consulted to determine where data are located and to ascertain that the most recent data sets are being used.

- SCEXT.DBF: As noted above, this file contains software extensions, their definitions, and the types of software that creates them. This file should be consulted to determine how a binary file might be used. The current contents of this file appear in Table 7-1.

- SCFLAGS.DBF: This file maps the common measurement flagging system used in the MZVS to specific flags associated with measurements from an individual measurement device and from individual networks. The common flags are defined in Table 7-2, and are intended to guide the data user to seek greater detail in the individual network flags. The network flags are also included, where available, in the data files, but they are not generally carried when data from different networks are integrated for data analysis and modeling.

- SCCONVRT.DBF: This file documents the conversions made in integrating data into the database. If, for example, wind speed units are changed from miles per hour to meters per second, then the change is documented in the file.

Table 7-2
Common Data Flags

0	Valid data
1	Estimated value
2	Calibration or instrument check
3	Instrument failure
4	Off-scale reading
5	Interpolated
6	Below detection limit
7	Suspect
8	Invalid
9	Missing
a	Hourly average, 45 min <= avg period < 60 min
b	Hourly average, avg period < 45 min
d	Averaged data
e	Zero mode
f	Blank sample

7.4.2 Database Structure

The database is organized by network with sub-directories for each source, as described in Section 7.2. Files within these sub-directories are further organized by the type of measurement. For example, surface meteorological data are contained in one file, while surface light scattering data are contained in another file. One file contains data of the specified type for the entire measurement period and all sites in the specified network. The records in each file are ordered by site (alphabetically), date, and time. For contiguous data, records are maintained for intervening periods even if no valid data were acquired for that period to facilitate time-series analysis. For example, if no valid data were available at 1000

7.4.3 Data File Naming Conventions

Data file names are coded to indicate the type of data, the network from which they were derived, the measurement period covered, and the averaging time for each measurement. File names follow the pattern "SSDDVPXY", where SS is the network/investigator (data source) code, DD is the data type code, V is the averaging interval code, P is the data collection time period code, and X and Y allow further differentiation by the analyst. For example, ARSMHP.DBF, is the file name for hourly (H) surface meteorological (SM) data taken by Air Resource Specialists, Inc. (AR) for the entire study period (P). Table 7-3 defines the codes used in this structure, and the full definitions of filenames is contained in the MZFILES.DBF file.

7.4.4 Data File Structure and Format Conventions

Each record in a data file provides the site code, measurement date, start time, data values, validation level, and individual validation flags. Site codes are consistent with the codes in the SCSITE.DBF file. This allows the site documentation files to interact. For example, simple queries formulated by data management software allow site coordinates to be associated with any variable value for spatial plotting. All times are in Pacific Daylight Time (PDT), even when local times are in a different time zone or follow standard time conventions. These times are listed as the beginning of the averaging period with 0000 for midnight of the current date. Where averaging times are variable, a sample duration is included as well as a sample stop time. All missing values are replaced by "-99" and flagged as invalid.

Each record includes a field (VAL) that shows the validation level for that record. The processes used to define the validation level are specified below. The last field in each record (SCFLG) contains the SCOS97 measurement validation flags. This field contains as many characters as there are data fields preceding the (SCFLG) field, and the position of the flag corresponds to the sequential position of the field to which it applies. This allows a compact method for identifying and filtering data that are valid, suspect, or invalid.

7.5 Data Validation Levels

Mueller (1980), Mueller et al., (1983), and Watson et al. (1983, 1989, 1995) define a three-level data validation process that should be mandatory in any environmental measurement study. Data records are designated as having passed these levels by entries in the VAL column of each data file. These levels, and the validation codes that designate them, are defined as follows:

- Level 0 (0): These data are obtained directly from the data loggers that acquire data in the field. Averaging times represent the minimum intervals recorded by the data

Table 7-3

SCOS97 Database File Naming Conventions

Data Source Codes:	
AI	AIRS database.
AR	Air Resources Board.
BL	Bureau of Land Management
FS	US Forest Service.
NO	National Oceanic and Atmospheric Administration.
NW	National Weather Service.
RA	Remote Automated Weather Station (RAWS) network.
MM	Minerals Management Service
SQ	South Coast Air Quality Management District
Data Type Codes:	
SA	Surface Air Quality Data (O_3, NO, NO2, NO_y, PAN, CO, SO_2)
VC	Surface Canister VOC Data
VO	Surface Continuous GC VOC Data
CB	Surface Cartridge Carbonyl Data
HW	Radar Profiler, High Resolution Wind Speed and Direction Data
LW	Radar Profiler, Low Resolution Wind Speed and Direction Data
PV	Radar Profiler, Virtual Temperature Data
SD	Sodar, High Resolution Wind Speed and Direction Data
RA	Rawinsonde Upper Air Wind Speed, Wind Direction, Temperature and RH Data
SM	Surface Wind Vane Wind Speed and Wind Direction Data
ST	Surface Temperature and Relative Humidity Data
SN	Surface Sonic Anemometer Wind Speed, Wind Direction, Temperature, and Turbulence Data
SS	Surface Solar Insolation Data
Averaging Interval Codes:	
B	6 hour samples
C	12 hour samples
D	24 hour samples
H	Hourly
I	Instantaneous (< 1 min)
M	15 minute samples
P	Partial hour samples (< 60 min)
Time Period Codes:	
P	Project Period
M	Intensive Operating Period 1
N	Intensive Operating Period 2
O	Intensive Operating Period 3

logger, which do not necessarily correspond to the averaging periods specified for the database files. Level 0 data have not been edited for instrument downtime, nor have procedural adjustments for baseline and span changes been applied. Level 0 data are not contained in the SCOS97 database, although they are consulted on a regular basis to ascertain instrument functionality and to forecast episodes prior to receipt of Level 1A data.

- Level 1A (1A): These data have passed several validation tests applied by the network operator that are specific to the network. These tests are applied prior to acquisition of data by the SCOS97 data manager. Specific tests appropriate for each measurement fielded in the SCOS97 are described elsewhere in this plan. The data quality indicator in the SCSITE.DBF file is a qualitative judgment of how stringent these Level 1A tests are when data from different networks are compared. The general features of Level 1A are: 1) removal of data values and replacement with -99 when monitoring instruments did not function within procedural tolerances; 2) flagging measurements when significant deviations from measurement assumptions have occurred; 3) verifying computer file entries against data sheets; 4) replacement of data from a backup data acquisition system in the event of failure of the primary system; 5) adjustment of measurement values for quantifiable baseline and span or interference biases; and 6) identification, investigation, and flagging of data that are beyond reasonable bounds or that are unrepresentative of the variable being measured (e.g. high light scattering associated with adverse weather).

- Level 1B (1B): After data are received by the data manager, converted, and incorporated into the database, validation at level 1B is performed. This is accomplished by software which flags the following: 1) data which are less than a specified lower bound; 2) data which are greater than a specified upper bound; 3) data which change by greater than a specified amount from one hour to the next; and 4) data values which do not change over a specified period, i.e., flat data. Data identified by these filters are individually examined and verified with the data supplier. Obvious outliers (e.g. high solar radiation at midnight, 300 °C temperature) are invalidated. Others may be invalidated or flagged based on the results of the investigation. The bounds used in these tests are determined by agreement between the project manager and the measurement investigators. If a datum fails one or more of the above tests it is flagged, and corrective action is taken. This action may require re-submission of the data. The tests are performed in the order given above.

- Level 2 (2): Level 2 data validation takes place after data from various measurement methods have been assembled in the master database. Level 2 validation is the first step in data analysis, and the detailed tasks are specified in Section 3.1. Level 2 tests involve the testing of measurement assumptions, comparisons of collocated measurements, and internal consistency tests.

- Level 3 (3): Level 3 is applied during the model reconciliation process, when the results from different modeling and data analysis approaches are compared with each other and with measurements. The first assumption upon finding a measurement which is inconsistent with physical expectations is that the unusual value is due to a measurement error. If, upon tracing the path of the measurement, nothing unusual is found, the value can be assumed to be a valid result of an environmental cause. The Level 3 designation is applied only to those variables that have undergone this re-examination after the completion of data analysis and modeling. Level 3 validation continues for as long as the database is maintained.

A higher validation level assigned to a data record indicates that those data have gone through, and passed, a greater level of scrutiny than data at a lower level. All data in the SCOS97 data set will achieve Level 1B status prior to use in data analysis and modeling. The validation tests passed by Level 1B data are stringent by the standards of most air quality and meteorological networks, and few changes are made in elevating the status of a data record from Level 1B to Level 2. Since some analyses are applied to episodes rather than to all samples, some data records in a file will achieve Level 2 designation while the remaining records will remain at Level 1B. Only a few data records will be designated as Level 3 to identify that they have undergone additional investigation. Data designated as Levels 2 or 3 validations are not necessarily "better" than data designated at Level 1B. The level only signifies that they have undergone additional scrutiny as a result of the tests described above.

7.6 Data Processing

For measurements acquired as part of the SCOS97, data are submitted by each investigator using the variable naming conventions and units described in SCFLDNAM.DBF. All values are to be at Level 1A when submitted. These are passed through the Level 1B tests described above, and discrepancies are resolved with the measurement investigator and corrected prior to designation as Level 1B. Data are added to the master data files as they are received.

Measurements from other networks, such as RAWS and the National Weather Service, are acquired in formats and units specific to those networks. Data processing functions are specific to these networks. First, these files are manually edited, when needed, because they sometimes contain minor variations in format that confound the data conversion programs. After editing, a network-specific data conversion program reads the data and converts it to an xBase file format with a single record for each measurement. Variable names in these intermediate file differ from those in SCOS97 files by designating the unit used for each measurement in the specified network. For example, field name "TA__F" indicates ambient temperature in degrees Fahrenheit as found in the NWS database rather than the "TA" field name for ambient temperature in degrees Celsius that is used in the SCOS97 data files.

The next step converts measurement units to the SCOS97 common units specified in SCFLDNAM.DBF. Conversion factors are accessed from a file that maps one unit into another based on the specification of the input and output variable names. In addition to changing units, the conversion program maps times, dates, missing values, and validation flags into the SCOS97 conventions described above. Conversions are documented by writing two records to a file entitled SCCONVRT.DBF. The first record gives the input file name and input file field names and the following record gives the output file name and output file field names, thereby documenting the conversions performed.

A data validation log is kept to document all changes made to the data files, including changes in the data validation level. This includes a record of the data changed, the reason for the change, and the date of the change. All data as originally submitted to the database are retained so that changes can be traced back to the original data.

8. EMISSION INVENTORY

Section 39607(b) of the California Health and Safety Code requires the California Air Resources Board (ARB) to inventory sources of air pollution within the 14 air basins of the state and to determine the kinds and quantities of pollutants that come from those sources. The pollutants inventoried are total organic gases (TOG), reactive organic gases (ROG), carbon monoxide (CO), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), and particulate matter with an aerodynamic diameter of 10 micrometers or smaller (PM_{10}). TOG consist of hydrocarbons including methane, aldehydes, ketones, organic acids, alcohol, esters, ethers, and other compounds containing hydrogen and carbon in combination with one or more other elements. ROG include all organic gases except methane and a number of organic compounds such as low molecular weight halogenated compounds that have been identified by the U.S. Environmental Protection Agency (EPA) as essentially non-reactive. For ROG and PM_{10}, the emission estimates are calculated from TOG and PM, respectively, using reactive organic fractions and particle size fractions. Emission sources are categorized as on-road mobile sources, nonroad mobile sources, stationary point sources, stationary area sources, and biogenic sources.

8.1 Emission Estimation Methodology

Point source emissions occur at facilities that can be identified by name and location and emit more than the threshold value specified by the local air pollution control district (APCD). A facility may have many individual identifiable sources (points) of emissions, and a point source may correspond to one or more processes or operations. Point-source activity levels usually relate to a process rate. Emission factors are derived from tests that relate emissions to the process causing the emissions. Point source emission estimates are based primarily upon data collected by the county APCDs and air quality management districts (AQMDs). For the 1990 SoCAB emission inventory, reported data are used for point sources emitting more than 2 tons per year of any one of the criteria air pollutants. Point source emission estimates are stored and maintained in the California Emission Inventory Development and Reporting System (CEIDARS), and are also reported to the national Aerometric Information Retrieval System (AIRS) which is maintained by the U.S. Environmental Protection Agency.

Most area sources are small emitters that are not accounted for in the point source portion of the CEIDARS database. Some examples of area sources are residential space heaters, agricultural burning, pesticide applications, and consumer products. Area source emission estimates are developed by the districts and by the ARB staff.

On-road mobile sources are motor vehicles that travel on public roads. This category consists of gasoline-powered and diesel-powered passenger cars, light-duty trucks (6,000 lbs. gross vehicle weight [GVW] or less), medium-duty trucks (6,001-8,500 lbs. GVW), heavy-duty trucks (over 8,500 lbs. GVW), urban buses, and motorcycles. Emissions from motor vehicles include exhaust, evaporative, crankcase, and tire-wear emissions. Four computer programs (CALIMFAC, WEIGHT7n, EMFAC7n, and BURDEN7n) are used to produce the motor vehicle emission inventories. These models are described in detail by the ARB (1995b). Model versions are indicated by the letter "n". Drafts of the next model version ("G") were released for public comment in December, 1995. The "CALifornia Inspection/Maintenance emission FACtor" (CALIMFAC) program computes base emission rates for each technology group with and without inspection and maintenance (I/M) benefits. The base emission rates consist of a zero mile rate and a deterioration rate for each model year for each pollutant. The "EMission FACtor" (EMFAC) model computes fleet composite emission factors by vehicle class and technology for a calendar year. The WEIGHT program provides EMFAC with activity weighting fractions for individual model years so that composite emission factors can be produced. WEIGHT also provides the accumulated mileage by model year for any particular calendar year in order to calculate the "deteriorated" emission rate for a model year. BURDEN calculates the emission estimates in tons/day by multiplying the composite emission factors from EMFAC by activity factors. Vehicle miles traveled, vehicle type distribution, and trip lengths, the input data for BURDEN are obtained from the California Department of Motor Vehicles (DMV) and the California Department of Transportation. BURDEN adjusts emission rates according to speed, ambient temperature, and heavy-duty I/M benefits.

Motor vehicle emission rates consist of running, incremental cold start, and incremental hot start exhaust emissions for TOG, CO, and NO_X, and hot soak, diurnal, running and resting evaporative emissions for TOG. Running exhaust emissions include emissions from the tailpipe or through the crankcase after the vehicle is warmed up and in a stabilized mode. Running exhaust emissions also include exhaust particulate matter and particulate matter from tire wear. Cold start emissions occur from the time the engine starts, after being off for one or more hours for a catalyst-equipped vehicle and four or more hours for a non-catalyst-equipped vehicle, until the coolant achieves its nominal operating temperature. Cold start emissions are incremental emissions that are added to the running emissions. The hot start mode occurs after a short engine-off period, less than one hour for a catalyst-equipped vehicle and less than four hours for a non-catalyst-equipped vehicle. Hot start emissions are also incremental to running emissions. Hot soak emissions result from gasoline vaporization from elevated engine and exhaust temperatures after the engine is turned off at the end of a trip. All of these emissions are assumed to be proportional to average vehicle miles traveled. The emission rates for hot soak emissions are expressed as grams of TOG per trip rather than as grams of TOG per vehicle mile traveled (VMT). Diurnal evaporative emissions result from the daily changes in the ambient temperature due to expansion of the air-fuel mixture in a partially filled fuel tank. Running evaporative losses are releases of gasoline vapor from the fuel system during vehicle operation (included for the first time in EMFAC7E). Resting loss evaporative emissions are due to fuel line hose or fuel tank permeation (included for the first time in EMFAC7F).

Three types of inventories are available from the ARB: daily average, planning, and gridded. The average daily emissions are expressed as an emission rate in tons per average day, determined by dividing annual emissions by 365. Countywide and basinwide totals are provided by source categories. This inventory is updated and published annually by the ARB. BURDEN can produce planning inventories which take into account the effects of diurnal and seasonal variations in temperature and activity patterns. The planning inventories provide emission estimates for six periods (0000-0600, 0600-0900, 0900-1200, 1200-1500, 1500-1800, and 1800-2400 PST or PDT) during an average summer and winter day. The Direct Travel Impact Model (DTIM) assigns emission rates to locations and time periods to provide input to air quality models. DTIM is BURDEN's analog for gridded inventories. DTIM was developed jointly by Caltrans and the ARB. DTIM uses the temporal and spatial distributions of motor vehicle activities provided by a travel demand model, the summarized composite vehicle emission rate from EMFAC, and an input file of parameters such as hourly temperatures by grid cell to calculate and distribute emissions into the grid system defined by the user. Emission backcasts and forecasts are made by the ARB using base year emissions in conjunction with estimates of growth and emission control effectiveness. Emission growth is based upon available projections of socio-economic trends. Emission reductions are based upon adopted regulations and control measures. Backcast and forecasts are also available for planning inventories.

A major emission control program that is currently altering the composition of ambient VOC in southern California is reformulated gasoline. Both the federal government and the State of California have developed specifications for reformulated gasoline (RFG). The Federal program is required for all severe and extreme ozone nonattainment areas, whereas the California program applies throughout the state. Both California and federal RFG are being introduced in two phases. California Phase 1 was introduced in 1992 and Phase 2 is scheduled for introduction in 1996. Phase I and Phase II of the federal program are scheduled for introduction in 1995 and 2000, respectively. Phase 1 gasoline currently sold in California has reduced RVP in summertime and 2 percent oxygen (about 11% methyl-tert-butyl ether) in winter. Average specifications for Federal Phase I gasoline include RVP of 7.1 psi, 2.0 percent by weight oxygen content, and 1.0 percent by weight benzene content. These requirements were effective as of January 1995, and apply to the South Coast Air Basin, Ventura County, and the San Diego Air Basin. The proposed California Phase 2 RFG specifications apply to all gasoline sold in California beginning March 1996, and include a maximum 80 ppmw sulfur content (average of 30 ppmw), a maximum 1.2 percent by volume benzene content (average of 0.8), maximum 10.0 percent olefin content, maximum 2.7 percent by volume oxygen content, maximum T90 and T50 of 330 °F and 220 °F, respectively, maximum 30 percent by volume aromatic hydrocarbon content (average of 20 percent), and a maximum RVP of 7.0 psi.

Compositional differences of vehicle exhaust from Transitional Low-Emission Vehicles (TLEVs) operating on conventional industry-average gasoline (RF-A) versus Phase 2 RFG were summarized by the ARB (1993c). The summary includes data from testing programs conducted by the ARB, the Auto/Oil AQIRP, and Chevron Research & Technology Company. For the composite FTP, the average weight fraction of n-alkanes decreased from 15.3 percent with RF-A to 8.5 percent with RFG, while the branched alkanes increased from 24.5 percent with RF-A to 35.8 percent with RFG. The relative abundance of cycloalkanes and alkynes remained unchanged, while olefins and oxygenates showed slight increases with RFG. Emissions of aromatic compounds decreased from 35.2 percent with RF-A to 27.7 percent with RFG. Differences were higher for specific compounds (e.g., benzene and MTBE). These compounds or their ratios may serve as useful markers for RFG. Compared to motor vehicles using gasoline meeting California Phase 1 RFG, ARB estimates that Phase 2 RFG will achieve about a 15 percent reduction in VOC from on-road motor vehicles and a six percent reduction in NO_X emissions (ARB, 1991a). Corresponding reductions in terms of emissions from all sources (mobile and stationary) are 4 and 2 percent for VOC and NO_X, respectively. Actual reductions in 1996 may be smaller than these estimates since gasoline marketed in 1995 must conform to the

Federal Phase I RFG specifications rather than California Phase 1 in severe and extreme ozone nonattainment areas. The ARB is currently sponsoring a study by the Desert Research Institute to monitor the changes in ambient VOC composition resulting from introduction of RFG in the SoCAB.

The motor vehicle emission factor and activity models consist of many input parameters which contribute, in varying degree, to the overall uncertainty in the estimates of total emissions from on-road motor vehicles. The evidence that NMHC emission inventories in urban areas may be seriously underestimated has important implications for ozone abatement and underscores the need for verification of emission inventories (Seinfeld, 1989; NRC, 1991). The consequence of underestimating ROG emissions is that air quality model predictions will not agree with observations and, if they do, will do so for the wrong reasons.

8.2 Emission Inventory Projects

Emission inventories are compiled and maintained by the APCDs and the ARB, and are regularly updated to incorporate improvements in emission models and input data. Many of the revisions and improvements are products of an on-going research program. Current studies in progress that could contribute to improvement in emission estimates for the SCOS97 emissions inventory are summarized below.

1. "Southern California Gridded Emission Inventory" — Systems Applications International. In anticipation of the SCOS97, the Air Resources Board has contracted SAI to prepare a draft inventory of anthropogenic emissions for the SCOS97 study domain. The primary objective of this contract is to prepare the basic components needed to construct a gridded inventory for the year 1990. The products of this contract will serve as a foundation for projecting future-year gridded inventories needed to model ozone episodes for SCOS97. Other objectives of the contract are to identify deficiencies in the draft inventory, document any problems in the inventory preparation process, and recommend solutions or further research to alleviate these problems and deficiencies.

2. "Southern California Ship Traffic Inventory" — United States Navy. During the winter of 1994-95, the Navy was involved in describing air pollution transport processes along the southern California coast and offshore water as part of an examination of the impact of ship emissions on Ventura County exceedances. As an outgrowth of this effort, the Navy is conducting an up-to-date ship inventory of traffic through the Santa Barbara Channel, and through its Sea Test Range off Point Mugu. The Navy is currently coordinating with various agencies on the collection of data. Any expansion of the effort to include offshore regions is subject to the availability of funds and personnel.

3. "Emission Inventory for Northern Mexico" - Radian Corporation. The objective of this World Bank-sponsored study is to assemble an emission inventory for northern Mexico with particular emphasis on precursors of secondary fine particles.

4. "Temporal and Spatial Distribution of Area Source Emissions in the Sacramento Area" - University of California, Davis. The objectives of this ARB-sponsored study is to develop improve methodology for determining the spatial and temporal distributions of area source emissions. The study places special emphasis on off-road mobile sources such as agricultural and construction equipment (VOC, NO_X and PM emissions), and small solvent use categories (VOCs).

5. "Emission Forecasting System Redesign" — California State University, Fullerton. The objective of this study is to design a new system for developing, storing, and reporting emission forecasts and trend data for various emission sources. The system will receive data from the districts and store them in three Oracle databases (Growth Profile, Rule Tracking/Control, and Seasonal Adjustments). These data, along with data from California Emission Inventory Development and Reporting System (CEIDARS), will provide inputs into the Emission Forecasting Module, which will in turn produce a Trend database and a file for GID as outputs. The system will provide full compatibility with CEIDARS, be flexible in updating and processing of growth and control data, and have open architecture to enable development of additional models without major redesign.

6. "Solvent Cleaning/Degreasing Source Category Emission Inventory" — E.H. Pechan & Associates, Inc. The objectives of this study are to: 1) determine the amount of solvent used in cleaning/degreasing operations in California by district by county for a specified base year; 2) develop emission factors for specific solvent categories and equipment types; 3) develop statistically valid reliability factors for these activity and emission factors; and 4) specify sources of information for future annual updates of the activity factors.

7. "Industrial Surface Coating – Wood Furniture and Fixture Emission Inventory" — University of California, Davis. The objectives of this study are to: 1) determine the amount of solvent used in wood furniture and fixture coating operations in California by district by county for a specified base year; 2) develop the appropriate emission factors; 3) develop statistically valid reliability factors for these activity and emission factors; 4) specify sources of information for future annual updates of the activity factors; and 5) develop chemical speciation profiles for an appropriate number of wood coating categories.

8. "Improvement of Speciation Profiles for Architectural and Industrial Coating Operations" — CalPoly, San Luis Obispo. The objectives of this project are to develop chemical species profiles for volatile organic compound emissions from: 1) architectural coating operations; 2) industrial maintenance operations; and 3) associated solvent use. The new profiles are to reflect changes in composition that have occurred in the last few years due to regulations designed to reduce the amounts of VOC emitted by these coatings.

9. "Determination of Variability of Leaf Biomass Densities of Conifers and Mixed Conifers Under Different Environmental Conditions in the San Joaquin Valley Air Basin" — Statewide Air Pollution Research Center, University of California, Riverside. The

objective of this study is to determine the variability of dry leaf biomass densities of naturally occurring vegetation species under different environmental condition in the SJVAB. These data will be used to enhance a biogenic emission inventory system specific for California.

10. "Agricultural Systems in the San Joaquin Valley: Development of Emission Estimates for Nitrogen Oxides" — University of California, Berkeley. The objective of this study is to estimate NO_X emissions from agricultural systems in the San Joaquin Valley from July through September, 1995. The contractor will measure NO_X fluxes in agricultural systems representing the most important fertilizer and irrigation management practices; identify environmental and soil characteristics that influence emissions; and develop spatially and temporally explicit estimates of emissions. Measurements of ammonia emissions as a function of these factors will also be included.

11. "Critical Evaluation of Biogenic Emission System for Photochemical Grid Modeling in California" — UCLA, UCR, and Sonoma Technology, Inc. The objectives of this study are to: 1) evaluate processes and databases used to prepare biogenic emission inventories for photochemical modeling in California's airsheds; 2) review and update biomass and emission factor databases; 3) assess the utility of high- and low-altitude aerial imagery to improve biomass databases; 4) critique current emission inventory models; 5) identify gaps in databases and needed research; and 6) develop verification procedures for biogenic emission estimates. The ARB's continuation of this work in cooperation with UCLA will also significantly improve the California biogenic emission inventory by empirical leaf biomass and biogenic emission factors measurements, as well as by integrating new information from land/water use maps into the gridded VOC biogenic emission inventory estimation process.

12. "South Central Coast Air Basin Biogenic Emission Inventory Improvement Project" — Contractor to be determined. The Ventura County Air Pollution Control District, utilizing a 105 Grant from EPA, will have a gridded VOC speciated biogenic emission inventory prepared for Ventura and Santa Barbara Counties.

13. "Development of Toxic Emission Factors from Source Test Data Collected Under the Toxic Hot Spots Program" — Energy and Environmental Research Corporation. The objectives of this study are to validate source test results available under the ARB's Air Toxic Hot Spot Program, analyze the data for specific processes and toxic substances, and develop emission factors to support the emission inventory process under the program.

An emission inventory development plan for SCOS97 will identify significant data gaps and uncertainties in the inventory, and necessary studies. Collection of day-specific (including day-of-the-week variations) emissions and activity factors will be the main focus of these additional efforts (e.g., traffic counts, aircraft traffic).

As described in Section 2, an accurate emission inventory is an important prerequisite to good air quality model performance. Evaluations of the emission inventory include comparison of motor vehicle emission rates with "real-world" on-road measurements and top-down evaluation of the emission inventory using comparisons between ambient and emission inventory pollutant ratios and VOC composition, and application of source apportionment techniques. These and other data analysis approaches are described in Chapter 11.

9. DATA ANALYSIS

Data analysis is an essential part of the database and model development components of SCOS97. Measurements, by themselves, say nothing about the causes of air pollution and the likely effects of emission reductions. It is only when these measurements are interpreted that relationships can be observed and conclusions can be drawn. Similarly, mathematical models cannot be expected to explain phenomena which are not conceptually defined. "Conceptual models" of pollutant emissions, transport, chemical transformation, and deposition must be formed so that the best mathematical formulations can be selected to describe them. The major goals of SCOS97 data analysis are:

- To evaluate the measurements for applicability to model input, parameterization, and verification.

- To describe the air quality and meteorology during the field study period and to determine the degree to which these measurements represent other summertime pollution levels.

- To further develop conceptual models of physical and chemical processes which affect ozone formation and transport in southern California.

While these goals provide guidance, concrete actions must be taken to attain them. These actions are described in the following data analysis plan. The plan is intended to:

- Identify data analysis objectives and hypotheses to be tested by applying data analysis methods.

- Specify data analysis work elements and the data to which they will be applied so that objectives may be met and hypotheses may be tested.

- Specify methods by which the data analysis tasks can be carried out and integrated into publications and reports to meet data analysis objectives.

Data analysis activities are defined here within the following topic areas: 1) measurement evaluation; 2) spatial, temporal, and statistical descriptions; 3) qualitative transport characterization; 4) dispersion characterization; 5) emission characterization; 6) quantitative transport characterization (pollutant fluxes); 7) ozone chemistry; 8) episode characterization; and 9) refinement of conceptual models. Activities are detailed in the following sub-sections.

9.1 Accuracy, Precision, Validity, and Equivalence of Field Measurements

There has never been a field study to date that did not require substantial examination and investigation of the measurements prior to their further use in data analysis and modeling. This first topic area is essential to all subsequent data analysis efforts, and needs to be performed as data are received into the database described in Section 7. Major concerns focus on: 1) accuracy of VOC peak identification, and proper, consistent quantification of total nonmethane hydrocarbons; 2) representativeness of meteorological measurements, especially those drawn from existing networks; 3) accuracy and precision of low-concentration measurements, especially NO_y and PAN; and 4) comparability of measurements taken from different networks with different procedures.

9.1.1 Evaluate the Precision, Accuracy, and Validity of Light and Heavy Hydrocarbon and Aldehyde Measurements

For sites and sampling periods which represent different expected mixtures of VOCs (e.g., background, fresh urban, aged urban, regional, forested, industrial), create scatterplots of the sum of measured species vs. total nonmethane VOC. Calculate slopes, intercepts and correlations and compare these among different sites and sampling times. Estimate the range of values for unaccounted hydrocarbons and the degree to which these differ at different sites. Compare the sum of identified VOC concentrations to total nonmethane VOCs and identify significant differences among sampling sites and sampling periods. Plot hydrocarbon profiles (bar charts of percent composition for each carbon number and for the lumped parameter classes used in photochemical models) and compare these among different sampling periods and sampling sites.

Compare the detailed speciation of quality assurance samples with the routine speciation from normal network samples. Ascertain which species are not typically identified in normal network samples. Estimate the feasibility and effort required to reduce existing chromatograms with unidentified peaks for more complete speciation of normal network samples. Examine a selection of chromatograms from routine analyses and determine the feasibility and value of re-processing these chromatograms for more complete speciation. Use collocated and replicate analysis results to determine an overall precision for hydrocarbon measurements. Examine the discrepancies between different analyses as a function of aging time in the canisters and attempt to quantify the extent to which the gaseous contents change with time.

Evaluate sampling and analysis methods for aldehyde measurements by comparing collocated and replicate measurements. Determine the extent to which reactions take place in sampling bags used in aircraft from collocated measurements of bag and cartridge sampling. See Fung et al. (1993) for examples.

9.1.2 Evaluate the Precision, Accuracy, and Validity of Nitrogenous Species Measurements

Create scatterplots and calculate slopes, intercepts, and correlation coefficients for normal sensitivity chemiluminescent NO_X, high sensitivity chemiluminescent NO_y measurements sites, and spectroscopic measurements (e.g., DOAS and TDLAS). Determine the equivalency of these different measurement methods by evaluating these plots and statistics. Examine differences among sites (along with calibration and performance test data) to attribute differences to instrument differences or to interferents in the sampled air streams (e.g. HNO_3 detected by chemiluminescence). Create scatterplots and statistics of collocated PANalyzer values. Explain differences in terms of measurement methods or environmental variables (e.g., interferents). Compare differences to propagated uncertainty intervals derived from performance tests and extrapolate the collocated uncertainties to other luminol PAN sampling sites in the network. Reconcile laboratory comparison data with field comparison data.

9.1.3 Evaluate the Precision, Accuracy, Validity, and Equivalence of Meteorological Data

Devise methods to compare upper air measurements of wind speed and direction from profilers, acoustic sounders, and surface wind towers and with corresponding measurements from radiosondes. Determine equivalent averaging layers and averaging times. Determine times of day (e.g., early morning, mid-day, and late-day) when these measurements are similar and when they are not. Draw conclusions regarding the equivalence of these methods. Compare surface measurements of wind speed and direction with the lowest elevation values from collocated profile, sonde, and sounder measurements. Stratify comparisons by time of day to obtain well-mixed and layered vertical structures. Determine when surface measurements are an adequate estimate of upper air winds and when they are not, both with respect to elevation above ground level and time of day.

9.1.4 Evaluate the Precision, Accuracy, Validity, and Equivalence of Solar Radiation Data

Compare nearby measurements from the spectral radiation, ultraviolet radiation, and total solar radiation instruments. Determine the extent to which total solar radiation and spectral radiation are correlated with the ultraviolet wavelengths which are most influential in photochemistry. Determine the equivalence or difference between measurements taken in the SCOS97 and existing networks.

9.2 Describe the Spatial, Temporal, and Statistical Distributions of Air Quality Measurements

More data will be produced by field monitoring than can be examined by <u>any</u> data analysis plan. Summaries need to be created which can serve as a guide to the database and for the formulation of hypotheses to be tested by more detailed analyses. These summaries may be examples drawn from a data display package (such as that which was developed to display data in real-time during the study). The database and display software could then be used in other data interpretation projects to provide support for their findings.

9.2.1 Examine Average Diurnal Changes of Surface Concentration Data

Create diurnal box plots (which graphically show quartiles, median, mean, and extrema) for the entire sampling period and for each hour at each site of ozone, NO, NO_2, and PAN concentrations. Note differences in the timing and intensity of peak values as a function of sampling site, episode, and stratification. Group sites for which diurnal variations behave in a similar manner. Compare these with plots from selected sites in prior summers where ozone and NO_x data are available. Evaluate the extent to which the summer of 1997 is similar to or different from prior summers.

Create diurnal box plots for each hour at each site of ozone, NO_2, and PAN (where available) for each episode and the stratified intensive sampling days. Superimpose diurnal average total VOC, total aldehyde, nitric acid, and particulate nitrate boxes for specified sampling periods. Note differences in the timing and intensity of peak values as a function of sampling site and how these are similar to or different from those of the longer-term averages.

Create diurnal box plots of surface temperature, relative humidity, insolation, sigma theta, and scalar wind speed for each hour at each site for the entire monitoring period and for the intensive episodes. Identify similarities and differences among sites and between the intensive episodes and the entire study period.

9.2.2 Examine Spatial Distributions of Surface Concentration Data

Plot spatial isopleths corresponding to each intensive episode sample for total VOCs, selected VOC surrogates (selected to represent reactivity class, sources of precursors, or end products), NO_x, NO_2, PAN, NO/NO_2, VOC/NO_x, and O_3. Note similarities and differences in patterns with time of day, pollutant, and from episode to episode.

9.2.3 Examine Statistical Distributions and Relationships Among Surface Air Quality Measurements

Combine hourly averages of air quality measurements into sample averages corresponding to VOC and aerosol samples. For each site, calculate averages, standard deviations, first second and third maxima (with date and time of occurrence), and minima (with date and time of occurrence) concentrations for each species measured. Identify differences between morning, afternoon and nighttime, sampling locations, episodes, and chemical observable. Give special attention to differences between rural vs. urban areas, SoCAB vs. other air basins, morning vs. afternoon vs. nighttime.

Combine hourly averages of continuous measurements into sampling periods corresponding to VOC and aerosol samples. For each site, calculate the temporal correlation coefficients for all measured variables. Identify those variables which are highly correlated (negatively or positively) with each other and identify observables which might be represented by a single surrogate at each site. Combine these surrogates with meteorological variables and note positive or negative correlations among them.

Perform Principal Component Analysis (PCA) on VOC and nitrogenous species. Calculate eigenvectors of the correlation matrix and perform a varimax rotation to identify empirical factors which explain the variability in the data. Describe these factors in terms of physical phenomena, and examine factor scores to determine when each factor has much greater than or much less than average influence at each site.

Using selected species concentrations, calculate spatial correlations for the intensive episode samples. Examine correlations and identify which sites are highly correlated (positively or negatively) with each other. Calculate eigenvectors of this correlation matrix, perform a varimax rotation, and plot the empirical orthogonal functions which are deemed significant. Use these to select surrogate sites which can be used to represent neighboring sites for different observables (the surrogates and the area which they represent may not be the same for all observables).

Plot surface wind roses for all data at selected times of the day on a single map. Identify when flow reversals take place and when wind speeds increase or decrease. Note which areas have the highest frequencies of calms and when they occur. Perform these analyses for meteorologically stratified cases. Perform analyses for stations near sea-level as well as those located on higher terrain, and compare and explain differences.

9.2.4 Examine Vertical Distribution of Concentrations from Airborne Measurements

Plot VOC (total and selected species, aldehydes (total and selected species), NO_2, NO, O_3, and b_{scat} as a function of altitude for each spiral. Note similarities and differences with respect to location, time of day, and chemical species. Give special attention to VOC speciation in morning samples (i.e., local emissions) over urban (motor vehicle), non-urban (biogenic), and industrial (oil-field) areas. Compare canister and cartridge samples of VOC and aldehydes taken in spirals with those taken in circles at the top of the spiral.

Plot spatial distributions of VOC (total and selected species, aldehydes (total and selected species), NO_2, NO, O_3, and b_{scat} along aircraft traverses (within the mixed layer). Note similarities and differences with respect to location, time of day, chemical species, and the spatial distributions derived from surface-based measurements. Compare concentrations along boundaries (long-range aircraft) with those measured at locations within the study domain and note similarities and differences.

9.2.5 Examine the Spatial and Temporal Distribution of Solar Radiation

From the radiometer data, estimate the photosynthetically active radiation (needed for deposition and biogenic emissions), direct beam solar radiation, diffuse solar radiation, visible radiation (for light extinction), incident flux, and actinic flux (at frequencies relevant to photochemical reactions. Create spatial and temporal plots of these observables. Describe differences between sites and time-of-day in terms of measurement uncertainty, meteorological and air quality parameters. Note the effects of clouds and smoke on different types of radiation.

9.3 Characterize Meteorological Transport Phenomena

This topic addresses the major mechanisms for the movement of air into, out of, and between the different air basins in both horizontal and vertical directions. This requires an examination of conditions near sea level and also just below, within, and above the inversion layer.

9.3.1 Determine Horizontal Transport Patterns and Intensities Into, Out of, and Within the Air Basins

Plot 0500, 1100, 1700, and 2300 horizontal windfields at three different heights (surface, within the mixed layer, and above the mixed layer) using continuous and radiosonde data. Examine the consistency of these flow vectors with those predicted from synoptic weather maps and pressure gradients. Note similarities and differences with respect to time of day, elevation, and episode. Associate the directions with the expected phenomena of low-level jet, slope flows, Catalina (and other) eddies, and bifurcation. Examine aircraft data to further describe the evolution of these phenomena. Determine the time of occurrence, spatial extent, intensity, and variability of these phenomena.

Plot detailed horizontal wind vectors as a function of height for the Cajon Pass, Soledad Canyon, San Gorgonio Pass, the Santa Susana Pass, and the California bight. Examine these to determine the intensity and duration of transport from the SoCAB into the SEDAB, Ventura County, and San Diego County. Note similarities and differences with respect to time of day, elevation, and episode.

Plot back-trajectories for critical receptors (e.g., ozone hot-spots, forested sites, and transport corridors) for each intensive episode at three elevations. Start trajectories at the time of maximum ozone concentration. Identify general areas over which air masses might have passed to reach these receptors. Classify sampling periods into categories which are likely to be influenced by different types of source areas (e.g., industry, traffic, forest). Track horizontal pollution movements (e.g., visibility analyses) and determine if ozone values at stations downwind can be traced to photochemical changes on precursors upwind.

9.3.2 Determine Vertical Transport Patterns and Intensities within the Modeling Domain

Examine wind flow patterns to identify convergence and divergence zones. Examine acoustic sounder, profiler, and aircraft meteorological data for evidence of vertical exchanges in these regions. Determine the extent to which surface air is transported above the mixed layer, or air above is transported into the mixed layer at these locations. Verify this with vertical profiles of pollutant concentrations from onboard aircraft measurements. Examine and describe the intensity and duration of upslope flows to estimate the amount and frequency with which pollutants might be transported above the mixed layer. Verify this with onboard aircraft pollutant measurements. Plot the vertical velocity structure as a function of time. Examine monostatic sounder data and profiler data to determine the degree of layering in the atmosphere, especially during the morning. Identify the locations of wind shears and their effect on layering. Note the differences in layers at different locations throughout the study area.

9.4 Characterize Meteorological Dispersion Processes

Dispersion processes address the mixing of pollutants within the mixing layer, especially elevated and ground-level emissions, dispersion within and between modeling grid cells, and transport to the surface where deposition of pollutants may occur.

9.4.1 Characterize the Depth, Intensity, and Temporal Changes of the Mixed Layer — Characterize Mixing of Elevated and Surface Emissions

Plot the spatial distribution of expected mixing depths derived from temperature soundings at 0500, 1100, 1700, and 2300. Examine sounding, aircraft, and profiler data to determine the accuracy of interpolations of mixing depths between the 4 per day soundings. Examine aircraft and profiler data for evidence of other layers within the mixed layer, their time of formation and dissipation, and their typical duration and intensity. Describe the changes in layers as a function of time, especially during the morning when rapid changes are taking place with heating. Associate changes in layers with changes in surface temperature and solar radiation.

Examine vertical mixing as a function of location and time of day using aircraft data and continuous profiler and acoustic sounder measurements. Estimate the times of day on which pollutants emitted from stacks, and pollutants carried over from the previous day above the mixed layer, will combine with pollutants emitted at the surface. Verify this by examining aloft and surface level concentrations which are associated with aged emissions.

9.5 Characterize Emissions

Emission data will be acquired in separate projects. If ambient measurements and emission data are correct, consistent relationships between the spatial, temporal, and meteorological variability in emissions and ambient measurements should be found. The tasks associated with this objective look for these relationships and will explain why they are observed or are not observed.

9.5.1 Determine the Consistency between Proportions of Species Measured in Ambient Air and those Estimated by Emission Inventories

Calculate the average VOC/NO_x and CO/NO_x ratios and ratios of selected species (e.g., acetylene/benzene, ethylene/acetylene, benzene/xylenes, carbon monoxide/selected VOCs, total aromatics/total VOC, total biogenic species/total VOC, $>C_{10}$/total VOC, benzene/VOC, MTBE/VOC) in source-dominated areas for samples which are expected to be dominated by fresh, local emissions (e.g., morning samples). Compare these ratios with those in emission inventory grid squares in the vicinity of the sampling site and with ratios in speciated profiles. If profiles are sufficiently speciated, perform Chemical Mass Balance modeling to apportion each species to a source type (e.g., evaporative emissions, solvents, refinery, tailpipe emissions, biogenics) and compare the ratios of source contributions to the ratios of total VOC emissions in nearby grid squares. Note consistencies and differences between ambient ratios and emission inventories and advance explanations for these differences. Define further investigations needed to reconcile the discrepancies (both further work on inventories and ambient/source sampling). Compare ratios from high ozone days with those on low ozone days and identify the presence or absence of different emissions at receptors on different types of days.

Calculate the average ratios of VOC/NO_x and ratios of selected species (e.g. homologous groups/total VOC, oxygenates/total VOC, methyl vinyl ketone and methyl acrolein/isoprene, other daughter products/precursors) for samples which are expected to contain end products of photochemical reactions. Compare these ratios with those in emissions inventory grid squares in the vicinity of the sampling site and with ratios in speciated profiles to determine the extent to which primary emissions and secondary products contribute to the entire VOC loading. Explain differences between inventoried and measured VOC/NO_x ratios in terms of chemical reactions, if possible.

Using existing VOC source profiles for the study region, calculate source contributions to VOC at selected receptor sites using a Chemical Mass Balance (Watson et al., 1984, 1990). Compare relative source contributions with the relative emission rates from these sources in grid squares in the vicinity of the sampling sites. Examine source contributions for consistency with the emission inventory with respect to geographic location and sampling times. See Fujita et al. (1992, 1994, 1995) for examples.

9.5.2 Determine the Effects of Meteorological Variables on Emissions Rates

Select representative sampling sites from major source regions (e.g., urban, industrial, biogenic, etc.) and examine concentrations of "marker" species for sources as functions of temperature, relative humidity, wind speed, and other environmental variables which are used to adjust emission factors. If possible, draw conclusions concerning the efficacy of current emission factors to respond accurately to changes in meteorological variables. Compare VOC source contributions when intermittent sources are known to operate and when they are known not to operate. Attempt to detect effects of different wind speeds, temperatures, solar radiation levels, and relative humidities on biogenic and industrial emissions.

9.5.3 Determine the Detectability of Day-Specific Emissions at Receptors

Examine day-specific emissions and identify sampling locations and times which correspond to fires, pesticide applications, spills, etc. From previous measurements of emission compositions, identify chemical species that are likely to be contributed by that source. Examine transport and dispersion patterns to determine the likelihood of influence at nearby sites. Compare the ambient concentrations at likely impact sites with concentrations at that site when day-specific emissions do not exist. Examine nearby sites and draw conclusions about the region of influence of intermittent emitters. Draw conclusions regarding the importance of intermittent emissions for ozone formation.

9.6 Characterize Pollutant Fluxes

It is hypothesized that upwind sources are major contributors to pollutant levels measured at different receptors along the flow paths from the SoCAB to the Mojave desert, San Diego County, and Ventura County. A "flux plane" is a rectangular cross-section which is perpendicular to the prevailing horizontal wind direction at a location between major emissions areas. The major transport pathways that are suspected of passing through these flux planes were specified in Section 2.

9.6.1 Define the Orientations, Dimensions, and Locations of Flux Planes

Examine windfields to identify areas in air that is transported across a boundary at vertical levels, especially at entry and exit points to the SoCAB. Specify the horizontal and vertical coordinates of these flux planes. Examine the usefulness of different conceptual definitions of flux (i.e., mass/unit area/time, mass/time, upwind/downwind concentrations along a wind vector). Estimate uncertainties due to: 1) mis-specifying the portion of ozone flux attributable to background vs. that generated in the upwind source area; 2) the effects of vertical and horizontal wind shears or reversals on the definition of the flux plane; 3) variations in wind speed and direction between measurements; 4) mis-specification of the boundary plane height; and 5) effects of wind speed and direction variability on flux estimates.

9.6.2 Estimate the Fluxes and Total Quantities of Selected Pollutants Transported Across Flux Planes

Using aircraft spiral and traverse data, lidar data, and ground-based concentration data for VOCs, NO_x, and O_3 coupled with average wind speeds that are perpendicular to the chosen flux planes, calculate the mg/m^2-sec of each pollutant which crosses each plane as a function of time of day. Compare the fluxes for the different planes and assign downwind fluxes to a combination of fresh pollutant generation and contributions from the upwind flux plane. Examine fluxes at different layers, especially at night, if major differences are observed in vertical concentrations and wind speeds. Plot vertical cross-sections of concentrations, wind speed, and direction.

Compare the magnitudes of inflow to and outflow from regions which are bordered by flux planes. Advance explanations for major differences between inflow and outflow. Using all relevant field study data, test the hypotheses that: 1) there is significant local generation of pollutants; 2) there is significant venting through the mixed layer; and 3) there is substantial reverse or lateral transport owing to eddies, nocturnal jets, and upslope/downslope flows.

9.7 Characterize Chemical and Physical Interactions

Ozone, several nitrogenous species, and significant portions of the VOCs found in the study domain are not emitted directly from sources, but form from precursors. In particular, it is necessary to determine where or when ozone concentrations are limited by the availability of NO_X or VOC. These issues are addressed within this topic

9.7.1 VOC and Nitrogen Budgets

Plot pie charts of VOC speciation (with species expressed as mg/m^3 carbon categorized into homologous groupings such as paraffins, olefins, aromatics, formaldehyde, other aldehydes, heavy hydrocarbons, unidentified peaks, and total nonmethane VOC minus sum of peaks and as average carbon number for $<C_{10}$ and $>C_{10}$) maps for morning, afternoon, and evening sampling periods, with the size of the pie proportional to the total VOC. Select relatively inert compounds (e.g., ethane and acetylene) as well as reactive species to help identify sources. Determine the extent to which total VOCs are accounted for as a function of location and time of day. Advance hypotheses regarding the compositions of the unidentified peaks and the unaccounted-for VOC. Test these hypotheses by examination of example chromatograms from source-oriented and receptor-oriented sampling sites and from direct samples of source emissions. Draw conclusions regarding the effects of these unidentified and unknown fractions on chemical mechanisms used in air quality models.

Plot pie charts of the gaseous and particulate nitrogen (NO, NO_2, HNO_3, PAN, HONO, and NO_3^-), and carbon (heavy and light VOCs, aldehydes, and organic aerosol carbon) as a function of location. Make the radius of each pie proportional to the total number of N, S, or C atoms, and make each wedge proportional to the number of N, S, or C atoms contributed by each species. Examine the distributions of these species among gaseous and particulate phases as a function of time and location.

9.7.2 Reconcile Spatial, Temporal, and Chemical Variations in Ozone, Precursor, and End-Product Concentrations with Expectations from Chemical Theory

Calculate pseudo-steady-state values of ozone using NO/NO_2 ratios (from maps generated in work element 2.2.1) and assumed photolysis rates. Compare the spatial distribution of these calculated values with the measured values plotted in earlier data analysis activities. Explain possible reasons for differences. Compare NO_2 plots to PAN plots to determine when NO_2 is less than PAN.

Calculate average VOC-OH reactivity and determine VOC vs. NO_X limitations. Estimate (from literature) typical VOC-OH rate constants for individual VOC species. Calculate an average VOC reactivity by weighting each rate constant by the proportion of total VOC represented by its corresponding species. Compare the resulting average rate constants at different types of sites (urban, rural, oilfield) and sampling times (morning, day, night) with the VOC-OH reactivity of a standard urban VOC mixture (~3500 $ppm^{-1}min^{-1}$). Stratify data near elevated point sources to separate periods when plumes are above the mixed layer from periods for which elevated plumes are within the mixed layer. Note similarities and differences with respect to site-type and time of day. Calculate adjusted VOC/NO_X ratios by multiplying a reference value of VOC/NO_X (for typical urban areas) by the ratio of the adjusted reference rate constant. Relate the results to bands of demarcation on an EKMA-type diagram between regions of VOC, combined, and NO_X limitation in producing ozone. Use the results to classify areas of the study domain into ones for which the ozone-forming potential is limited by VOC or NO_X.

Simulate ozone-producing potential of ambient VOC samples using an accepted chemical mechanism (e.g., CBM-IV, RADM, SAPRC) in a simple box using a range of diurnal radiation profiles from the radiometers. Artificially add NO_X concentrations and calculate time to formation of peak ozone and the amount of ambient carbon carried over or available for reaction the next day for an assumed radiation intensity and time. Define an "ozone-forming-potential" figure of merit and map these as a function of location, time, and VOC level. Estimate the effects of VOC, radiation, and other measurement uncertainties on ozone-forming potential. Identify differences in potential owing to changes in the model mechanisms (e.g., compare results from CBM-IV with SAPRC and RADM).

Stratify episodes by high and low photochemical potential days, and compare photochemical products along trajectories estimated by other data analyses. Further stratify these episodes by VOC/NO_X ratios in the western and northern parts of the study domain and estimate the extent to which this ratio affects the maximum ozone levels in the eastern and southern portions of the study domain. Performing the same analyses as above for ozone levels in South Central Coast Air Basin for cases of southeast flow at the surface and/or aloft. Recalculate VOC/NO_X ratios for specific reactivity classes, especially aromatics, and examine receptor area ozone concentrations for cases of high and low ratios in the source areas. Examine the emission maps to compare the quantity of fresh hydrocarbon and NO_X injected along the trajectories, and determine the degree to which this might interfere with the conclusions drawn from the VOC/NO_X ratios in the source areas.

Examine aircraft traverses and compare ozone, NO_X, and VOC levels to simple equilibrium calculations. Examine nighttime concentrations of O_3 and precursors above the mixed layer and off the coastline to determine the degree of carryover from the previous day. Compare VOC/NO_X ratios above the mixed layer with those calculated from localized emissions grid squares near the northern and western boundaries of the study domain. Identify potential causes of discrepancies, if they are found.

Compare day-to-day changes in emission patterns (using day-specific inventories) with O_3 and VOC concentrations for otherwise similar meteorological conditions. Compare oxidant values in cases with high ambient aromatic VOC concentrations to values obtained when aromatic VOCs are low.

9.7.3 Apply and Evaluate Ozone Receptor Models to Determine VOC and NO_x Limitations

Several receptor-oriented models have been developed and applied to determining relationships between oxides of nitrogen, VOC, and ozone levels. In each case, evaluate and determine the applicability of these models to SCOS97 by evaluating their fundamental assumptions as part of applying them to appropriate measurements from the database.

Compute correlations and regression relationships between ozone, NO_X and NO_y for measurement locations with fresh and aged emissions. Determine the extent to which ozone increases in photochemically aged air when NO_y is less than 1 ppb and when it is higher than 10 ppb (e.g., Trainer et al., 1993; Jacob et al., 1995). Calculate Integrated Empirical Rates (e.g., Johnson, 1984, Blanchard et al., 1994; Chang et al., 1995) to determine at what downwind distances from major source regions NO_X reductions or VOC reductions would most affect ozone concentrations. Compare these distances with those determined by other methods. Examine ratios among ozone and nitrogenous species (e.g., Sillman et al., 1990; Sillman, 1995; Milford et al., 1994; Jacob et al., 1995; Watkins et al., 1995) to estimate when VOC and NO_X limitations might apply. Apply the observation-based model (OBM) of Cardelino and Chameides (1995).

9.8 Characterize Episodes

Each of the episodes of two- to four-day duration has similarities and differences with respect to emissions, meteorology, transformation, deposition, and air quality levels. These episodes may be high for similar or for different reasons. Information derived the preceding activities is synthesized to provide an anatomy of each episode. Conclusions are drawn with respect to which episodes are, for all practical purposes, the same, and which ones are substantially different.

9.8.1 Describe Each Intensive Episode in Terms of Emissions, Meteorology, and Air Quality

Prepare written overviews of each intensive sampling period. Describe the synoptic meteorology leading up the episode and summarize the forecasting rationale. Illustrate, with plots generated in other work elements, the general wind flows for the duration of the period and any deviations from these generalizations. Identify major emissions events, identified as significant in other work elements, which affected pollutant concentrations. Summarize the key pollutant concentrations at key times and key locations in the study domain. Summarize the completeness and validity of the data set from each episode with respect to modeling of ozone. Identify the transport and transformation mechanisms that are likely to be dominant in each episode. Evaluate each episode for its potential use in model testing and control strategy evaluation.

9.8.2 Determine the Degree to which Each Intensive Episode is a Valid Representation of Commonly Occurring Conditions and its Suitability for Control Strategy Development

Examine continuous meteorological and air quality data acquired for the entire study period, and determine the frequency of occurrence of days which have transport and transformation potential similar to those of the intensive study days. Generalize this frequency to previous years, using existing information for those years.

9.9 Reformulate the Conceptual Model

The conceptual model described in Section 2 must be revisited and refined using the results yielded by the foregoing data analyses. New phenomena, if they are observed, must be conceptualized so that a mathematical model to describe them may be formulated and tested. The formulation, assumptions, and parameters in mathematical modules which will be included in the integrated air quality model must be examined with respect to their consistency with reality.

9.9.1 Refine Conceptual Models of Pollutant Emissions

Specify motor vehicle emission model equations, assumptions, input data, and uncertainties. Reconcile the ambient species ratios found in ambient data (as studied in prior work elements) with ratios determined from emissions models in terms of model or measurement biases. By stratifying samples, estimate the effects of different meteorological variables on emission rates. Pay special attention to the validity of models regarding vehicle age, maintenance, effects of hot and cold operating conditions, and vehicle-type distributions. Recommend improvements to emission models based on these observations.

Specify biogenic emission model assumptions, input data, and uncertainties. Reconcile ambient hydrocarbon species ratios at sites located in agricultural and forested areas with those determined from emission models in terms of model or measurement biases. By stratifying samples, estimate the effects of different meteorological variables, especially wind speed, on emission rates. Examine chemical speciation as a function of vegetation type. Examine total ammonia concentrations as a function of nearby soil types and fertilizer applications. Recommend improvements to emission models based on these observations.

Specify oilfield and refinery emission model assumptions, input data, and uncertainties for cogeneration systems, diesel-powered internal combustion engines associated with pumps, natural gas plants, drilling rigs, remote operations, spills, leaks from valves and flanges, evaporation from storage tanks, cyclic and non-cyclic well head vents, sumps, measuring stations, evaporation from tanker trucks and loading racks, pumping stations, and vacuum trucks, and gasoline stations. Evaluate how well these emissions estimates relate to reality, and which variables are not included in current methodology.

Reconcile ambient hydrocarbon species ratios at sites located near sewage plants and feedlots with those determined from emission models in terms of model or measurement biases. By stratifying samples, estimate the effects of different meteorological variables, especially temperature and relative humidity, on emission rates. Recommend improvements to emission models based on these observations.

Intermittent events include fires, entertainment and sporting events, and industrial upsets. Specify the models which treat intermittent events, their assumptions, and input data. Examine the magnitude of emissions from intermittent events with respect to other emissions to determine whether or not these emissions are significant. Recommend improvements to emission models based on these observations.

Examine the variability in emissions for intensive analysis days. Compare this variability to that assumed by point source models. Recommend improvements in emission models based on these observations.

9.9.2 Refine Models of Pollutant Transport and Dispersion

Thermal lows are caused by surface heating over the Mojave Desert and are one of the major causes of flow between the SoCAB and the SEDAB. Specify meteorological model assumptions and input data relevant to calculating the vertical profile of this transport pathway. For unidirectional flows, the mathematical formulation should show a minimum in turbulence or laminar flow occurring at the height of the wind maximum, and the width of the jet should be adequately estimated. The model formulation should allow this region of minimal turbulence to intensify the nighttime inversion in the vicinity of the flow and to inhibit vertical transport. Reconcile the model formulation with the location, dimensions, intensity, duration, and frequency of the thermal low transport. Quantify and compare measurement and model uncertainties.

Upslope flows in the San Gabriel and San Bernardino Mountains result from heating of the mountain sidewalls by the afternoon. The downslope flows commence after sunset when the slopes cool. When the intensity of these up-slope winds is large, pollutants are vented from the SoCAB into the air above the mixed layer, and possibly into neighboring air basins. Examine the assumptions and input data of the meteorological model which relate to slope flows. Determine whether or not the intensity and timing of these flows corresponds to those observed in other data analysis work elements. Identify those cases in which upslope flows vent pollutants above the mixed layer or over the summit, and determine the extent to which the mathematical formulation can represent these cases. Identify areas of uncertainty in the modeling and measurement processes and attempt to quantify these uncertainties.

Marine airflows from the California Bight mix, age, and transport pollutants from one air basin to another. These airflows develop primarily from strong coast-to-inland pressure gradients. The most visible artifact of these flows is the marine stratus that forms along the coastal areas. A stronger inversion, a feature of the subtropical high, is usually present above the marine stratus layer and may extend to heights of 100 to 1000 m ASL, sufficiently deep to extend over the coastal mountains. Examine the results of windflow analysis to determine where and when this transport phenomenon occurs. Determine the presence or absence of fogs and high humidity at night, with the intent of understanding whether or not NO_x transported off the coast can be rapidly transformed to particulate nitrate which could be advected on-shore during the next day. Examine meteorological model formulation for those features which will describe these flows. Identify uncertainty in the modeling and measurement processes and attempt to quantify these uncertainties. Compare different pollutants with diurnal/spatial variations in humidity, visibility, cloud cover, and solar radiation for the same air mass.

Identify the occurrence and thickness of different atmospheric layers from other data analysis work elements. Determine the modeled layer structure. Examine the extent to which layers can be assumed to be uniform, or must vary in depth as a function of location and time. Evaluate the uncertainty introduced to the modeling process by anticipated deviations from layering assumptions.

9.9.3 Evaluate Boundary Conditions for Models

VOC concentrations are usually assumed to be constant or negligible at the western and northern boundaries and at the top of the study domain. Specify the values which have been used in previous modeling and the sensitivity to changes in them. Plot airborne measurements of VOCs (total VOC, homologous groups, and lumped VOC classes) along boundaries and above the mixed layer, then examine the magnitude and constancy of their concentrations in space and time. List assumptions and input data requirements for VOC boundary conditions, and estimate the effects of uncertainties caused by insufficient data on the ability of the model to represent reality.

Nitrogenous species concentrations are usually assumed to be constant or negligible at the western and northern boundaries and at the top of the study domain. Plot airborne measurements of NO, NO_2, and PAN along boundaries and above the mixed layer, then examine the magnitude and constancy of their concentrations in space and time. Specify the model assumptions for boundary conditions of nitrogenous species, and estimate the effect if deviations from those assumptions on chemical concentrations.

9.9.4 Evaluate Initial Conditions for Models

Each grid square and each layer in the modeling domain starts with a concentration for each chemical species. These must be estimated from a sparse network of ambient measurements. Examine the different methods by which initial conditions are estimated from surface and airborne measurements. State the equations, assumptions, inputs, and uncertainties for these methods. Determine which methods are most applicable to the single point and aircraft measurements. Determine which methods are most useful for approximating initial conditions for integrated air quality modeling.

9.9.5 Evaluate Chemical and Physical Transformation Models

State the equations, assumptions, and input data for ozone formation. Identify those species in these models which were measured during SCOS97. Evaluate the uncertainties introduced by non-continuous, 2-hour VOC measurements, variations in solar radiation, and uncertainties in boundary and initial conditions.

9.9.6 Evaluate Pollutant Deposition Models

Specify the equations, assumptions, input data, and uncertainties for the deposition model. From the examination of micrometeorological data and vertical flux measurements, determine the extent to which these equations represent reality, and the degree to which assumptions are complied with. Evaluate the effects of input data uncertainties on deposition estimates.

10. BUDGET ESTIMATES

Cost estimates have been prepared for each element of the core and optional programs based on a consensus of the SCOS97 Technical Committee and Working Groups on measurement priorities for the study. Cost estimates are summarized in Table 10-1 for major components of the proposed measurement plan. Detailed itemized costs are provided in Tables 10-2 to 10-9. These estimates shown vary in detail and accuracy. Some cost are based on contracts already in place, some on unit costs for similar measurements that are being made in existing ARB extramural contracts or cost quotations from vendors, and remaining estimates are based on the costs of similar programs rather than on detailed analyses of labor and materials required for each component. In the aggregate, these costs serve to identify the general cost scope of the proposed study. The total contract costs for SCOS97 is $3,450,000 for the core program and $1,830,000 for optional elements for a total combined contract costs of $5,280,000.

In addition to the above extramural contract costs, the ARB and the air pollution control districts in southern California, and the U.S. Navy have committed in-kind resources for planning and execution of SCOS97. Estimate of in-kind cost are estimated by multiplying the projected level of effort (in hours) by a nominal hourly rate of $75 (including overhead). Only additional efforts that are specifically required to execute SCOS97 are included in the in-kind cost estimates. The total in-kind costs for is $1,300,000 for the core program and $170,000 for optional elements for a total combined in-kind costs of $1,470,000.

Table 10-1
Summary of Cost Estimates for the 1997 SCOS Field Measurement Program

Element	Table #	Core Program In-Kind Cost ($)	Core Program Contracts Cost ($)	Core Program Total Cost ($)	Optional Elements In-Kind Cost ($)	Optional Elements Contracts Cost ($)	Optional Elements Total Cost ($)	Total In-Kind Cost ($)	Total Contracts Cost ($)	Total Project Cost ($)
Preliminary Studies	Table 10-2	$87,000	$0	$87,000	$3,000	$0	$3,000	$90,000	$0	$90,000
Site Aquisition, Preparation, and Documentation	Table 10-3	$12,000	$104,000	$116,000	$12,000	$104,000	$116,000	$24,000	$208,000	$232,000
Supplemental Surface Measurements	Table 10-4									
Ozone		$5,000	$40,000	$45,000	$5,000	$40,000	$45,000	$10,000	$80,000	$90,000
NO2, NOx, NOy & PAN		$42,800	$60,800	$103,600	$34,500	$47,000	$81,500	$77,300	$107,800	$185,100
Additional Met Sites		$3,800	$12,500	$16,300	$3,800	$12,500	$16,300	$7,600	$25,000	$32,600
Management, Coordination and Other Cost		$0	$22,800	$22,800	$0	$21,000	$21,000	$0	$43,800	$43,800
TDLAS/DOAS (2 each)						$150,000	$150,000	$0	$150,000	$150,000
VOC Measurements	Table 10-5									
Routine PAMS			$0	$0			$0	$0	$0	$0
IOP Surface Canisters		$109,300	$177,100	$286,400			$0	$109,300	$177,100	$286,400
IOP Surface Carbonyl		$63,900	$69,300	$133,200			$0	$63,900	$69,300	$133,200
Aircraft Canisters			$149,000	$149,000		$77,000	$77,000	$0	$226,000	$226,000
Aircraft Carbonyl			$49,000	$49,000		$24,700	$24,700	$0	$73,700	$73,700
Upper-Air Meteorology and Air Quality	Table 10-6									
NOAA Radar Wind Profilers/SODARS		$284,000	$850,000	$1,134,000			$0	$284,000	$850,000	$1,134,000
Radar Wind Profilers - 5 Additional				$0		$400,000	$400,000	$0	$400,000	$400,000
SODARs - 8 Additional				$0		$200,000	$200,000	$0	$200,000	$200,000
Radiosondes (Augment Military Releases)		$18,000	$67,200	$85,200			$0	$18,000	$67,200	$85,200
Radiosondes (Supplementary Sites)			$266,400	$266,400						
CE-CERT Ozonesondes			$535,000	$535,000			$0	$0	$535,000	$535,000
Instrumented Tall Building		$75,000		$75,000			$0	$75,000	$0	$75,000
NOAA 2D Ozone Lidar w/RWP&RASS		$80,000	$402,000	$482,000			$0	$80,000	$402,000	$482,000
Sandia Ozone Lidar				$0		$320,000	$320,000	$0	$320,000	$320,000
Aircraft Operations	Table 10-6									
Aircraft #1			$247,000	$247,000			$0	$0	$247,000	$247,000
Aircraft #2			$150,000	$150,000			$0	$0	$150,000	$150,000
Aircraft #3			$150,000	$150,000			$0	$0	$150,000	$150,000
Aircraft #4			$350,000	$350,000		$0	$0	$0	$350,000	$350,000
Field Operations and Management	Table 10-7	$203,000	$143,000	$346,000			$0	$203,000	$143,000	$346,000
Quality Assurance	Table 10-8									
QA Plan		$0	$30,000	$30,000	$0	$0	$0	$0	$30,000	$30,000
QA Coordination (1 person x 500 hrs)		$37,500	$0	$37,500	$12,000	$0	$12,000	$49,500	$0	$49,500
Ozone and NOx (2 persons x 10 sites x 32 hrs)		$48,000	$0	$48,000	$18,000	$0	$18,000	$66,000	$0	$66,000
Nitrogen Species			incl. w/contract	$0			$0	$0	$0	$0
Volatile Organic Compounds Audits (1 person x 160 hrs)		$48,000	$0	$48,000	$0	$0	$0	$48,000	$0	$48,000
Independent VOC QA and data validation		$0	$50,000	$50,000	$0	$0	$0	$0	$50,000	$50,000
Aloft Air Quality Data Validation		$12,000	(a)	$12,000	$12,000	$0	$12,000	$24,000	$0	$24,000
Surface Meteorology		$0	$20,000	$20,000	$0	$15,000	$15,000	$0	$35,000	$35,000
Upper-Air Meteorology QA and validation		$24,000	$0	$24,000	$24,000	$0	$24,000	$48,000	$0	$48,000
Data Management	Table 10-8	$144,000	$0	$144,000	$48,000	$0	$48,000	$192,000	$0	$192,000
Emission Inventory Development	Table 10-9	$100,000	$100,000	$200,000		$100,000	$100,000	$100,000	$200,000	$300,000
TOTAL		$1,397,300	$4,045,100	$5,442,400	$172,300	$1,511,200	$1,683,500	$1,569,600	$5,556,300	$7,125,900

Table 10-2

Cost Estimate for Preliminary Analyses and Support Studies

Item	Core Program			Optional Elements		
	In-Kind Cost ($)	Contracts Cost ($)	Total Cost ($)	In-Kind Cost ($)	Contracts Cost ($)	Total Cost ($)
Independent Lidar Evaluations - NOAA		(a)	$0			
Independent Lidar Evaluations - Sandia (NO_x + O_3)				$3,000	(a)	$3,000
Develop and Evaluate Forecast Protocol (6 persons x100 days x 1 hr/day)	$45,000		$45,000			
Evaluate NO_x/NO_y instruments (2 persons x 40 hours)	$6,000	incl. with QA	$6,000			
Evaluate PAMS VOC Measurements (4 persons x 120 hours)	$36,000	incl. with QA	$36,000			
TOTAL	$87,000	$0	$87,000	$3,000	$0	$3,000

(a) included with UCD contract

Table 10-3

Cost Estimate for Site Acquisition, Preparation, and Documentation

Item	Unit Cost ($)	Core Program: Number of Units	Core Program: In-Kind Cost ($)	Core Program: Contract Cost ($)	Core Program: Total Cost ($)	Optional Elements: Number of Units	Optional Elements: In-Kind Cost ($)	Optional Elements: Contract Cost ($)	Optional Elements: Total Cost ($)
Acquire/rent sites									
Air Quality/Surface Met Site - new	$2,500	5		$12,500	$12,500	5		$12,500	$12,500
Air Quality/Surface Met Site - at existing site	$2,000	5		$10,000	$10,000	5		$10,000	$10,000
Subtotal				$22,500	$22,500			$22,500	$22,500
Install/remove power, fencing, tower, etc.									
Air Quality/Surface Met Site - new	$5,600	5		$28,000	$28,000	5		$28,000	$28,000
Air Quality/Surface Met Site - at existing site	$700	5		$3,500	$3,500	5		$3,500	$3,500
Subtotal				$31,500	$31,500			$31,500	$31,500
Trailer/building rental (5 mo.) and trailer towing									
Air Quality/Surface Met Site - new	$2,700	5		$13,500	$13,500	5		$13,500	$13,500
Air Quality/Surface Met Site - at existing site	$700	5		$3,500	$3,500	5		$3,500	$3,500
Subtotal				$17,000	$17,000			$17,000	$17,000
Power bills									
Air Quality/Surface Met Site - new	900	5		$4,500	$4,500	5		$4,500	$4,500
Air Quality/Surface Met Site - at existing site	900	5		$4,500	$4,500	5		$4,500	$4,500
Subtotal				$9,000	$9,000			$9,000	$9,000
Communications									
Installation & equipment	1300	5		$6,500	$6,500	5		$6,500	$6,500
Service Charge	500	5		$2,500	$2,500	5		$2,500	$2,500
Site Documentation	1000	5		$5,000	$5,000	5		$5,000	$5,000
Management & Coordination (4 persons x 40 hours)	10% of above		$12,000	$9,400	$21,400		$12,000	$9,400	$21,400
TOTAL			$12,000	$103,400	$115,400		$12,000	$103,400	$115,400

Table 10-4

Supplemental Surface Air Quality and Meteorological Measurements

		Core Program				Optional Elements			
Item	Unit Cost ($)	Number of Units	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)	Number of Units	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)
Cost Estimate for Equipment Purchase or Rental (not including VOCs)									
Ozone	$8,000	5	$5,000	$40,000	$45,000	5	$5,000	$40,000	$45,000
NO2/NOx/NOy/PAN - LPA4 (a)	$8,250	5		$41,250	$41,250	4		$33,000	$33,000
Meteorology	$2,500	5	$3,750	$12,500	$16,250	5	$3,750	$12,500	$16,250
Data acqusition system	$1,100	5		$5,500	$5,500	5		$5,500	$5,500
	Subtotal		$8,750	$99,250	$108,000		$8,750	$91,000	$99,750
Contractors Mark-up	5%		$0	$4,963	$4,963		$0	$4,550	$4,550
TOTAL			$8,750	$104,213	$112,963		$8,750	$95,550	$104,300
LPA4 Operations									
Operator Training	$2K/session	5	$1,500	$2,000	$3,500	4	$1,500	$0	$1,500
Installation/Removal	$1,000	5		$5,000	$5,000	4		$4,000	$4,000
Calibration Checks/Troubleshoot	$2,500	5		$12,500	$12,500	4		$10,000	$10,000
Routine Operations		5	$26,250		$26,250	4	$21,000		$21,000
Data Processing/Validation		5	$15,000		$15,000	4	$12,000		$12,000
	Subtotal		$42,750	$19,500	$62,250		$34,500	$14,000	$48,500
TDLAS/DOAS						2 each		$150,000	$150,000
Management & Coordination	10% of above		0	$12,371	$12,371		0	$10,955	$10,955
TOTAL			$51,500	$136,084	$187,584		$43,250	$270,505	$313,755

(a) Leased at 5%/month * 5 months * $25,000

Table 10-5
Cost Estimate for VOC Measurement Systems and Analyses

Item	Days	Sites	#/day	Unit Cost ($)	Core Program: Samples PAMS	Core Program: In-Kind Cost ($)	Core Program: Samples Contract	Core Program: Contract Cost ($)	Optional Elements: Samples Contract	Optional Elements: Contract Cost ($)
Routine PAMS HC										
SCAQMD Auto-GC	90	2	8		1440					
SCAQMD Canister/GC	30	4	8		960					
VCAPCD Canister/GC	30	3	4		360					
SDAPCD Canister/GC	30	4	4		480					
Routine PAMS Carbonyls										
SCAQMD	30	3	8		720					
VCAPCD	30	1	4		120					
SDAPCD	30	2	4		240					
IOP Surface Canisters										
VCAPCD Canister/GC	10	3	4	$350	120	$ 42,000				
SDAPCD Canister/GC	10	4	4	$350	160	$ 56,000				
SoCAB										
Canister rental				$120			150	$18,000		
Canister sampler				$2,500			5	$12,500		
Sample Collection (4/day/site)						$11,250				
Analysis - C2-C12 HC, MTBE	15	5	4	$350			300	$105,000		
Analysis - CO, CO2, and CH4	15	5	4	$60			300	$18,000		
Canister shipping				$25			300	$7,500		
QC and Extra Samples	10%	of IOP total						$16,100		
Subtotal						$ 109,250		$177,100		
IOP Surface Carbonyl										
VCAPCD (Type 2)	10	1	4	$140	40	$ 5,600				
SDAPCD (Type 2)	10	2	4	$140	80	$ 11,200				
VCAPCD (Type 1,3)	15	2	4	$140	120	$ 16,800				
SDAPCD (Type 1,3)	15	2	4	$140	120	$ 16,800				
Carbonyl cartridges				$8			360	$2,880		
Carbonyl sampler				$1,500			6	$9,000		
Sample Collection (4/day/site)						$13,500				
SoCAB	15	6	4	$140			360	$50,400		
Cartridge Shipping				$2			360	$720		
QC and Extra Samples	10%	of IOP total						$6,300		
Subtotal						$ 63,900		$69,300		
Aircraft Canister Measurements	Days	Flight/ day	No./ Flight							
VOC Canister rental/shipping				$120			128	$15,300	68	$8,100
VOC sampler rental				$2,500			3	$7,500	1	$2,500
Shipping				$30			255	$7,650	135	$4,050
Analysis - C2-C12 HC, MTBE	15	3,2,2[a]	3,2,2	$350			255	$89,250	135	$47,250
Analysis - CO, CO2, and CH4	15	3,2,2	3,2,2	$60			255	$15,300	135	$8,100
QC and Extra Samples	10%	of IOP total						$13,500		$7,000
Subtotal						$0		$148,500		$77,000
Aircraft Carbonyl Measurements										
Carbonyl cartridges				$13			255	$3,315	135	$1,755
Carbonyl sampler rental				$1,500			3	$4,500	1	$1,500
Shipping				$2			255	$510	135	$270
Carbonyl analysis	15	3,2,2	3,2,2	$140			255	$35,700	135	$18,900
QC and Extra Samples	10%	of IOP total						$4,403		$2,243
Subtotal						$0		$48,428		$24,668
TOTAL						$ 173,150		$ 443,328		$ 101,668

a Three numbers correspond to Aircraft #1, #2, and #3, respectively. Optional for fourth aircraft.

Table 10-6

Cost Estimate for Upper-Air Meteorology and Air Quality

Item				Unit Cost ($)	Core Program: In-Kind # of Units	Core Program: In-Kind Cost ($)	Core Program: Contract # of Units	Core Program: Contract Cost ($)	Optional Elements: Contract # of Units	Optional Elements: Contract Cost ($)
Routine Upper-Air Meteorology	Days	Sites	#/day							
Radar Wind Profiler/RASS, in-kind	153	8	Cont.		8					
Radar Wind Profiler/RASS, NOAA	153	11	Cont.			$284,000	10	$850,000		
Radar Wind Profiler, NWS	153	(10)	Cont.							
SODAR, NOAA	153	3	Cont.				3	ncl. w/RWP		
Radar Wind Profiler/RASS, NOAA	153	5	Cont.						5	$400,000
SODAR, (additional in coastal plane)		8	Cont.						8	$200,000
Subtotal						$284,000		$850,000		$600,000
IOP Upper-Air Meteorology	Days	Sites	#/day							
Radiosondes (Augment Existing Military Rele	15	4	2	$560	120	$18,000	120	$67,200		
Radiosondes (Supplemental Sites) Expendabl	15	4	4	$560			240	$134,400		
Radiosondes (Supplemental Sites) Ground Stations		4		$24,000			4	$96,000		
Radiosondes (Supplemental Sites) Labor	15	4	4	$150			240	$36,000		
RWP and RASS, NOAA			375					incl. w/Lidar		
Subtotal						$18,000		$333,600		$0
IOP Upper-Air Ozone and NOx	Days	Sites	#/day							
CE-CERT Ozonesondes	15	6	4			$0	360	$535,000		$0
Instrument Tall Building						$75,000				
NOAA 2D Ozone Lidar			375 hrs.			$80,000		$402,000		
Sandia Ozone Lidar			375 hrs.							$320,000
Subtotal						$155,000		$937,000		$320,000
Aircraft Operations	Days	Flights								
Air quality aircraft #1 (UCD)(a)	15	3					45	$247,000		
Air quality aircraft #2 (Gibbz Navajo)	15	2					30	$150,000		
Air quality aircraft #3 (Gibbz Cessna)	15	2					30	$150,000		
Air quality aircraft #4 (Backup/rover)	15	2					30	$350,000		
Subtotal								$897,000		$0
TOTAL						$457,000		$3,017,600		$920,000

Table 10-7
Cost Estimate for Field Operations and Management

Item	Core Program			Optional Elements		
	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)
Field Operations Center						
Office Space	SCAQMD		$0			
Utility	SCAQMD		$0			
Telephone system	SCAQMD		$0			
Phone lines	SCAQMD		$0			
Cellular Phone		$10,000	$10,000			
Pagers 20 @ $60/mo. - 3 mo.		$3,600	$3,600			
Answering Machine		$150	$150			
3 PC with internet access		$9,000	$9,000			
Workstation and storage device		$20,000	$20,000			
Misc Equipment and Supplies		$50,000	$50,000			
Office furniture	SCAQMD		$0			
Office supplies	SCAQMD		$0			
Subtotal	$0	$92,750	$92,750			
Field Management						
Program Management	$108,000		$108,000	$36,000		$36,000
5 person x120 days x 2 hrs/day x $75/hr			$0			
Forecast team	$94,500		$94,500			
6 persons x 105 days x 2 hr/day x $75/hr			$0			
Field manager - AD (Hering)		($44,000) DRI	$0			
SCOS Field Study Report		$50,000	$50,000		$15,000	$15,000
Subtotal	$202,500	$50,000	$252,500	$36,000	$15,000	$51,000
TOTAL	$202,500	$142,750	$345,250	$36,000	$15,000	$51,000

Table 10-8

Cost Estimate for Quality Assurance and Data Management

Item	Core Program			Optional Elements		
	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)
Quality Assurance						
QA Plan		$30,000	$30,000			
QA Coordination (1 person x 500 hrs)	$37,500		$37,500	$12,000		$12,000
Ozone and NOx (2 persons x 10 sites x 32 hrs)	$48,000		$48,000	$18,000		$18,000
Nitrogen Species		incl. with contract	$0			
Volatile Organic Compounds Audits (1 person x 160 hrs)	$48,000		$48,000			
Independent VOC QA and data validation 5% of total VOC contract amount		$50,000	$50,000			
Aloft Air Quality Data Validation	$12,000	(a)	$12,000	$12,000		$12,000
Surface Meteorology		$20,000	$20,000		$15,000	$15,000
Upper-Air Meteorology QA and validation	$24,000		$24,000	$24,000		$24,000
Subtotal	$169,500	$100,000	$269,500	$66,000	$15,000	$81,000
Data Management (2 persons x 960 hrs)	$144,000		$144,000	$48,000		$48,000
TOTAL	$313,500	$100,000	$413,500	$114,000	$15,000	$129,000

(a) Included with UCD contract

Table 10-9
Cost Estimate for Emission Inventory Development

Item	Core Program			Optional Elements		
	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)	In-Kind Cost ($)	Contract Cost ($)	Total Cost ($)
Traffic Count Data		$100,000	$100,000			
Airport Activity Data					$100,000	$100,000
Shipping Lane Inventory (U.S. Navy)	$100,000					
Biogenic Emissions		existing				
Total	$100,000	$100,000	$200,000	$0	$100,000	$100,000

11. REFERENCES

Altshuller, A.P. and S.P. McPherson (1963). "Spectrophotometric Analysis of Aldehydes in the Los Angeles Atmosphere." *J. Air Pollut. Contr. Assoc.*, **13**, 109.

Altshuller, A.P. and T.A. Bellar (1963). "Chromatographic Analysis of Hydrocarbons in the Los Angeles Atmosphere." *J. Air Pollut. Contr. Assoc.*, **13**, 81.

Altshuller, A.P., G.C. Ortman, B.A. Saltzman and R.E. Neligan (1966). "Continuous Monitoring of Methane and Other Hydrocarbons in Urban Atmospheres." *J. Air Pollut. Contr. Assoc.*, **16**, 87.

Altshuller, A.P., W.A. Lonneman, F.D. Sutterfield, and S.L. Kopczynski (1971). "Hydrocarbon Composition of the Atmosphere of the Los Angeles Basin--1967." *Environ. Sci. Technol.*, **5**, 1009.

Ancellet, G., A. Papayannis, J. Pelon, and G. Mégie (1989). "DIAL Tropospheric Ozone Measurement Using a Nd:YAG Laser and the Raman Shifting Technique." *J. Atmos. Oceanic Technol.* **6**, 832-839.

Angell, J.K., C.R. Dickson and W.H. Hoecker, Jr. (1975). "Relative Diffusion Within the Los Angeles Basin as Estimated from Tetroon Triads." *J. Appl. Meteorol.*, **14**, 1490.

Angell, J.K., C.R. Dickson and W.H. Hoecker, Jr. (1976). "Tetroon Trajectories in the Los Angeles Basin Defining the Source of Air Reaching the San Bernardino-Riverside Area in Late Afternoon." *J. Appl. Meteorol.*, **15**, 197.

AQIRP, Technical Bulletin No. 1 (1990). "Initial Mass Exhaust Emissions Results from Reformulated Gasolines, Auto/Oil Air Quality Improvement Research program, December, 1990.

Ashbaugh, L.L., W.C. Malm and W.Z. Sadeh (1985). "A Residence Time Probability Analysis of Sulfur Concentrations at Grand Canyon National Park." *Atmos. Environ.*, **19**, 1263.

Ashbaugh, L.L., D. Lawson, B. Johnson, S. Huang, G. Bishop, P. Guenther, D. Stedman, R. Stephens, P. Groblicki and J. Parikh (1992). "On-Road Remote Sensing of Carbon Monoxide and Hydrocarbons Emissions During Several Vehicle Operating Conditions." In *Transactions, PM_{10} Standards and Nontraditional Particulate Source Controls*, J.C Chow and D.M. Ono, Eds. Air & Waste Management Association, Pittsburgh, PA, pp. 885-898.

Atkinson, R. (1989). Kinetics and Mechanisms of Gas-Phase Reactions of the Hydroxyl Radical with Organic Compounds. *J. of Physical and Chemical Reference Data,* Monograph No. 1.

Bastable, H.G., D.P. Rogers and D.E. Schorran (1990). "Tracers of Opportunity and Pollutant Transport in Southern California." *Atmos. Environ.*, **24B**, 137-151.

Bigler-Engler V. (1995a). "Analysis of an Ozone Episode During the San Diego Air Quality Study: The Significance of Transport Aloft". In Regional Photochemical Measurement and Modeling Studies. Editor E.D. Ranzieri and P.A. Solomon, **VIP-48,** A&WMA, Pittsburgh PA.

Bigler-Engler, V. and H.W. Brown, (1995b). Analysis of an Ozone Episode During the San Diego Air Quality Study: The Significance of Transport Aloft. *J. Appl. Meteor.*, **34**:1363-1376.

Bishop, G.A., J.R. Starkey, A. Ihlenfeldt, W.J. Williams and D.H. Stedman (1989). "IR Long Path Photometry: A Remote Sensing Tool for Automobile Emissions." *Anal. Chem.*, **61**, 671A.

Bishop, G.A. and D.H. Stedman (1990). "On-road Carbon Monoxide Emission Measurement Comparisons for the 1988-1989 Colorado Oxy-fuels Program." *Environ. Sci. Technol.*, **24**, 843.

Blumenthal, D.L., W.H. White and T.B. Smith (1978). "Anatomy of a Los Angeles Smog Episode: Pollutant Transport in the Daytime Sea Breeze Regime." *Atmos. Environ.*, **12**, 893.

Blumenthal, D.L., T.B. Smith, D.E. Lehrman, N.L. Alexander, F. Lurmann and D. Godden (1986). Analysis of Aerometric and Meteorological Data for the Ventura County Region. STI Report #90094-511-FRS to the Western Oil and Gas Association, Los Angeles, CA.

Blumenthal D.L., J.G. Watson, and P.T. Roberts. 1987. *Southern California Air Quality Study (SCAQS) Program Plan*, final report prepared for California Air Resources Board.

Blumenthal, D.L. and J.G. Watson (1991). "SJVAQS/AUSPEX Collaborative Field Study Plan." Paper No. 91-70.6 presented at the A&WMA 84th Annual Meeting, Vancouver, B.C.

Browell, E. V. (1982). "Lidar Measurements of Tropospheric Gases." *Opt. Eng.* **21**, 128-132.

Browell, E. V., S. Ismail, and S. T. Shipley (1985). "Ultraviolet DIAL Measurements of O_3 Profiles in Regions of Spatially Inhomogeneous Aerosols." *Appl. Opt.* **24**, 2827-2836.

California Air Resources Board (1986). "State of California Air Resources Board Emissions Inventory 1983." Prepared by the Stationary Source Control Division, Emission Inventory Branch, California Air Resources Board, Sacramento, CA.

California Air Resources Board (1990a). "Emission Inventory 1987." Technical Support Division, Emission Inventory Branch, Sacramento, CA.

California Air Resources Board (1990b). "Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations Within California." Technical Support Division and Office of Air Quality Planning and Liaison, Sacramento, California.

California Air Resources Board (1991a). "Emission Inventory 1989." Technical Support Division, August 1991.

California Air Resources Board (1991b). "California Phase 2 Reformulated Gasoline Specifications - Volume 1 Proposed Regulations for California Phase 2 Reformulated Gasoline, October 1991.

California Department of Motor Vehicles (1991). DMV Forecasting and MIS Unit, Fee-Paid Vehicle Registrations, 1976-1990.

California Air Resources Board (1992). "California Air Pollution Control Laws--1992 Edition." Sacramento, California.

California Air Resources Board (1992). "Draft Modeling Emissions Data System." Control Strategy Modeling Section, Technical Support Division, California Air Resources Board, Sacramento, CA.

California Air Resources Board (1993a). "Establishment of Corrections to Reactivity Adjustment Factors for Transitional Low-Emission Vehicles and Low-Emission Vehicles Operating on Phase 2 Reformulated Gasoline," Research Division, California Air Resources Board, Sacramento, CA, March 1993.

California Air Resources Board (1993b). "Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations in California." Technical Support Division, Sacramento, California.

California Air Resources Board (1994). Emission Inventory 1991. Prepared by the Technical Support Division, January 1994.

Calvert, J.G. (1976). "Hydrocarbon Involvement in Photochemical Smog Formation in Los Angeles Atmosphere." *Environ. Sci. Technol.*, **10**, 256.

Carter, W.P.L (1994). "Development of Ozone Reactivity Scales for Volatile Organic Compounds." *J. Air & Waste Manage. Assoc.* **44**:881-899.

Cass, G.R. (1978). "Methods for Sulfate Air Quality Management with Applications to Los Angeles." California Institute of Technology, Pasadena, CA, **2**, 1.

Cass, G.R. and F.H. Shair (1984). "Sulfate Accumulation in a Sea Breeze/Land Breeze Circulation System." *J. Geophys. Res.*, **89**, 1429.

Causley, M.C. and G.M. Wilson (1991). "Seasonal and Annual Average Biogenic Emissions for the South Coast Air Basin Generated by the SCAQMD Biogenic Database System." Prepared for South Coast Air Quality Management District. Contract #90177. Systems Applications International, San Rafael, CA.

Charlson, R. J. (1972). "Multiwavelength Nephelometer Measurements in Los Angeles Smog Aerosol." *J. Colloid Interface Sci.* **39**, 240-265.

Chico, T., M.E. Bassett and J.C. Cassmassi (1995). "Application of the Urban Airshed Model for a SCAQS Episode in the South Coast Air Basin." In *Southern California Air Quality Study--Data Analysis*, E.M. Fujita Ed., VOIP-26, Air & Waste Management Association, Pittsburgh, PA, pp. 257-263.

Chow, J.C., E.M. Fujita, J.G. Watson, Z. Lu, D.R. Lawson, and L.L. Ashbaugh (1994). "Evaluation of Filter-Based Aerosol Measurements During the 1987 Southern California Air Quality Study." *Environ. Sci. Technol.* **30**:49-80.

DaMassa, J., P. Allen, T. McGuire, D. McNerny, A.J. Ranzieri, and K. Wagner (1992). "Photochemical Modeling." A Technical Guidance Document, California Environmental Protection Agency; Air Resources Board.

Davidson, J. A., C. A. Cantrell, A. H. McDaniel, R. E. Shetter, S. Madronich, and J. G. Calvert (1988). "Visible-Ultraviolet Absorption Cross Sections for NO_2 as a Function of Temperature." *J. Geophys. Res.* **93**, 7105-7112.

Davidson, A. (1993). "Update on Ozone Trends in California's South Coast Air Basin," *J. Air Waste Manage. Assoc.* **43**:226.

de Jonge, C. N., J. B. Bergwerff, and D. P. J. Swart (1991). "Using 'DIAL' to Measure Freeway Traffic NO_2 Emissions." In Technical Digest on Optical Remote Sensing of the Atmosphere, *Optical Society of America* (Washington, D.C.) **18**, 250-252.

Douglas, S.G., R.C. Kessler, C.A. Emery and J.L. Burtt (1991). "Diagnostic Analysis of Wind Observations Collected During the Southern California Air Quality Study, Final Report." Prepared under Contract No. A832-133 for Research Division, California Air Resources Board, Sacramento, CA, by Systems Applications International, San Rafael, CA.

Drivas, P.J. and F.H. Shair (1974). "A Tracer Study of Pollutant Transport and Dispersion in the Los Angeles Area." *Atmos. Environ.*, **8**, 1155.

Edinger, J.G. (1959). "Changes in the Depth of the Mixing Layer over the Los Angeles Basin." *J. Appl. Meteorol.*, **16**, 219.

Edinger, J.G. and R.A. Helvey (1961). "The San Fernando Convergency Zone." *Bulletin of the American Meteorological Society*, **42**, 626.

Edinger, J.G., M.H. McCutchen, P.R. Miller, B.C. Ryan, M.J. Schroeder, and J.V. Behar (1972). "Penetration and Duration of Oxidant Air Pollution in the South Coast Air Basin of California." *J. Air Pollut. Contr. Assoc.*, **23**, 882.

Edinger, J.G. (1973). "Vertical Distribution of Photochemical Smog in the Los Angeles Basin." *Environ. Sci. Technol.*, **7**, 460.

Estoque, M.A. (1968). "Discussion of the Marine Layer and its Relation to a Smog Episode in Riverside, CA." *Atmos. Environ.*, **2**, 623.

Farber, R.J., A.A. Huang, L.D. Bregman, R.L. Mahoney, D.J. Eatough, L.D. Hansen, D.L. Blumenthal, W.S. Keifer and D.W. Allard (1982a). "The Third Dimension in the Los Angeles Basin." *Sci. Total Environ.*, **23**, 345.

Farber, R.J., L.C. Murray and I.R. Straughan (1982b). "An Objective Technique for Classifying Ambient Air Quality Parameters: Developed Using O_3 and NO_2 Episodes in the Los Angeles Basin." Presented at 75th Annual Meeting, New Orleans, LA. Air Pollution Control Association, Pittsburgh, PA.

Feigley, C.E. and H.E. Jeffries (1979). "Analysis of Processes Affecting Oxidant and Precursors in the Los Angeles Reactive Pollutants Program (LARPP) Operation 33." *Atmos. Environ.* **13**, 1369.

Federal Register (1993). "Ambient Air Quality Surveillance; Final Rule." 40 CFR Part 58, February 12, 1993.

Fernald, F. G., B. M. Herman, and J. A. Reagan (1972). "Determination of Aerosol Height Distributions by Lidar." *J. Appl. Meteor.* **11**, 482-489.

Fisk, C., 1996. "Hourly Climatology for Gaviota Vortex" Geophysics Branch Technical Report No. 190, May 1996.

Fisk, C., 1996. "Hourly Climatology for Laguna Peak" Geophysics Branch Technical Report No. 191, June 1996.

Fitz, D., M. Chan, G. Cass, D. Lawson, and L. Ashbaugh. 1989. A multi-component size-classifying aerosol and gas sampler for ambient air monitoring. A&WMA paper 89-140.1. Presented at the 82nd Annual Meeting of the Air & Waste Management Association, Anaheim, CA, 1989.

Fujita, E.M. (1992). "Comparison of Emissions and Ambient Concentrations of CO, NO_x and NMOG in California's South Coast Air Basin." Doctoral dissertation, University of California, Los Angeles, CA, University Microfilms International, Ann Arbor, MI.

Fujita, E.M., B.E. Croes, C.L. Bennett, D.R. Lawson, F.W. Lurmann and H.H. Main (1992). "Comparison of Emission Inventory and Ambient Concentration Ratios of CO, NMOG, and NO_x in California's South Coast Air Basin." *J. Air Waste Manage. Assoc.*, **42**, 264.

Fujita, E.M. 1993. Southern California Air Quality Study; Data Analysis, ED. E.M. Fujita., *A&WMA*, **VIP**-26, Pittsburgh, PA.

Fujita, E.M., J.G. Watson, J.C. Chow and Z. Lu (1994). "Validation of the Chemical Mass Balance Receptor Model Applied to Hydrocarbon Source Apportionment in the Southern California Air Quality Study," *Environ. Sci. Technol.* **28,** 1633-1649.

Fujita E. M., Z. Lu, N.F. Robinson, and J.G. Watson (1995). VOC Source Apportionment for the Coastal Oxidant Assessment for Southeast Texas. Final Report, prepared for the: Texas Natural Resource Conservation Commission, Austin, TX, by the Desert Research Institute, Reno, NV, 31 August 1995.

Galle, B., A. Sunesson, and W. Wendt (1988). "NO_2-Mapping Using Laser-Radar Techniques." *Atmos. Environ.* **22**, 569-573.

Gibson, F. W. (1994). "Variability in Atmospheric Light-Scattering Properties with Altitude." *Appl. Opt.* **33**, 4919-4929.

Grant, W. B., R. H. Kagann, and W. A. McClenny (1992). "Optical Remote Measurement of Toxic Gases." *J. Air & Waste Manage. Assoc.* **42**, 18-30.

Green, M.C., R.C. Flocchini and L.O. Myrup (1992a). "The Relationship of the Extinction Coefficient Distribution to Wind Field Patterns in Southern California." *Atmos. Environ.*, **26A**, 827.

Green, M.C., L.O. Myrup and R.C. Flocchini (1992b). "A Method for Classification of Wind Field Patterns and its Application to Southern California." *Internat. J. Climatol.*, **12**, 111.

Grisinger, J.E., M. Yamada, G. Thomas, J. Maloney, P. Wuebben and R. Bradley (1982).

Gordon, R.J., H. Mayrsohn and R.M. Ingels (1968). "C2-C5 Hydrocarbons in the Los Angeles Atmosphere." *Environ. Sci. Technol.*, **2**, 1117.

1979 Emissions Inventory for the South Coast Air Basin." Revised October 1982. Prepared for South Coast Air Quality Management District, El Monte, CA.

Grosjean, D. (1982). "Formaldehyde and Other Carbonyls in Los Angeles Ambient Air." *Environ. Sci. Technol.*, **16**, 254.

Grosjean, D., R.D. Swanson and E.C. Ellis (1983). "Carbonyls in Los Angeles Air: Contribution of Direct Emissions and Photochemistry." *Sci. Total Environ.*, **29**, 65.

Grosjean, D. and K. Fung (1984). "Hydrocarbons and Carbonyls in Los Angeles Air." *J. Air Pollution Contr. Assoc.*, **34**, 537.

Grosjean, D. (1992). "In-situ Organic Aerosol Formation During a Smog Episode." *Atmos. Environ.*, **26A**, 953.

Harley, R.A., M.P. Hannigan and G.R. Cass (1992). "Respeciaiton of Organic Gas Emissions and the Detection of Excess Unburned Gasoline in the Atmosphere." *Environ. Sci. Technol.*, **26**, 2395.

Harley, R.A., A.G. Russell, G.J. McRae, G.R. Cass and J.H. Seinfeld (1993). "Photochemical Modeling of the Southern California Air Quality Study." *Environ. Sci. Technol.*, **27**, 378.

Hayes, T.P., J.J.R. Kinney and N.J.M. Wheeler (1984). California Surface Wind Climatology, California Air Resources Board, Sacramento, CA.

Hering, S.V. and D.L. Blumenthal (1989). Southern California Air Quality Study (SCAQS) Description of Measurement Activities. Final report to the California Air Resources Board, Contract A5-157-32.

Hester, N.E., E.R. Stephens and O.C. Taylor (1974). "Fluorocarbons in the Los Angeles Basin." *J. Air Pollut. Contr. Assoc.*, **24**, 591.

Hidy, G.M. and S.K. Friedlander. 1972. The nature of the Los Angeles aerosol. Second IUAPPA Clean Air Congress, Washington, D.C., 1972.

Hidy, G.M., B.R. Appel, R.J. Charlson, W.E. Clark, S.K. Friedlander, D.H. Hutchison, T.B. Smith, J. Suder, J.J. Wesolowski, and K.T. Whitby. 1975. Summary of the California aerosol characterization experiment. J. Air Pollut. Control Assoc. 25:1106.

Hitschfeld, W. and J. Bordan (1954). "Errors Inherent in the Radar Measurement of Rainfall at Attenuating Wavelengths." *J. Meteor.* **11**, 58-67.

Horie, Y., S. Sidawi and R. Ellefsen (1990). "Inventory of Leaf Biomass and Emission Factors for Vegetation in the South Coast Air Basin." Prepared under Contract #90163 for South Coast Air Quality Management District, El Monte, CA, Valley Research Inc., Van Nuys, CA.

Hossain, M.I. and M.R. Kaszuba (1994). "San Diego Air Quality Study -- Perspectives, Accomplishments, and Lessons." In Regional Photochemical Measurement and Modeling Studies. Editor E.D. Ranzieri and P.A. Solomon, **VIP-48,** A&WMA, Pittsburgh PA.

Husar, R.B., D.E. Patterson, D.L. Blumenthal, W.H. White and T.B. Smith (1977). "Three-Dimensional Distribution of Air Pollutants in the Los Angeles Basin." *J. Appl. Meteorol.*, **16**, 1089.

Ireson, R.G. and H. Hogo (1983). "Sensitivity of Peak Ozone Concentrations in the San Bernardino Desert to Local Emissions of VOC and NO_x." Prepared for the San Bernardino County Air Pollution Control District by Systems Applications International, 101 Lucas Valley Road, San Rafael CA 94903.

Kauper, E.K. and C.J. Hopper (1965). "Utilization of Optimum Meteorological Conditions for the Reduction of Los Angeles Automotive Pollution." *J. Air Pollut. Contr. Assoc.*, **15**, 210.

Kauper, E. and B. Niemann (1975). Los Angeles to Ventura Over Water Ozone Transport Study. California Air Resources Board, Sacramento, CA.

Kauper, E. and B. Niemann (1977). Los Angeles to San Diego Three-Dimensional Ozone Transport Study. California Air Resources Board, Sacramento, CA.

Keislar, R.E., D.E. Schorran and D.R. Lawson (1994). "Cool Water Ozone Feasibility Study Report." Desert Research Institute, January, 1994, 23 pages plus figures and tables.

Keislar, R.E. and D.E. Schorran (1995). Monitoring of Halocarbon Tracers of Opportunity at

Barstow, California. Paper 95-MP6.06, presented at the Air & Waste Management Association (A&WMA) 88th Annual Meeting, San Antonio, TX, 18-23 June 1995.

Keith, R.W. and B. Selik (1977). "California South Coast Air Basin Hourly Wind Flow Patterns." South Coast Air Quality Management District, El Monte, CA.

Klett, J. D. (1981). "Stable Analytical Inversion Solution for Processing Lidar Returns." *Appl. Opt.* **20**, 211-220.

Knapp, K. (1992). "Dynamometer Testing of On-Road Vehicles from the Los Angeles In-Use Emissions Study." In *Transactions, PM_{10} Standards and Nontraditional Particulate Source Controls*, J.C. Chow and D.M. Ono. Eds., Air & Waste Management Association, Pittsburgh, PA, pp. 871-884.

Kok, G.L. (1983). "Measurements of Formaldehyde and Hydrogen Peroxide in the California South Coast Air Basin." Document #EPA-600-S3-83-030. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Kopczynski, S.L., W.A. Lonneman, F.D. Sutterfield and P.E. Darley (1972). "Photochemistry of Atmospheric Samples in Los Angeles." *Environ. Sci. Technol.*, **6**, 342.

Kotin, P., H.L. Falk, P. Madar and M. Thomas (1954). "Aromatic Hydrocarbons. I. Presence in the Los Angeles Atmosphere and the Carcinogenicity of Atmospheric Extracts." *Archives of Industrial Hygiene*, **9**, 153.

Kovalev, V. A. and J. L. McElroy (1994). "Differential Absorption Lidar Measurement of Vertical Ozone Profiles in the Troposphere that Contains Aerosol Layers with Strong Backscattering Gradients: A Simplified Version." *Appl. Opt.* **33**, 8393-8401.

Kovalev, V. A. and H. Moosmüller (1994). "Distortion of Particulate Extinction Profiles Measured by Lidar in a Two-Component Atmosphere." *Appl. Opt.* **33**, 6499-6507.

Lawson, D.R.. (1988). The nitrogen species methods comparison study--an overview. Atmos. Environ. 22:1517, and accompanying papers pp. 1519-1672.

Lawson, D.R., P.J. Groblicki, D.H. Stedman, G.A. Bishop and P.L. Guenther (1990). "Emissions from In-Use Motor Vehicles in Los Angeles: A Pilot Study of Remote Sensing and the Inspection and Maintenance Program." *J. Air Waste Manage. Assoc.*, **40**, 1096.

Lawson, D.R. and S.V. Hering. 1990. The carbonaceous species methods comparison study--an overview. Aerosol Sci. Technol. 12:1, and accompanying papers pp. 3-213 (1990).

Lawson, D.R. 1990. The Southern California Air Quality Study. J. Air Waste Manage. Assoc. 40:156.

Lawson, D.R., E.M. Fujita and J.R. Holmes, 1995. The Southern California Air Quality Study; A Prototype for Collaborative Research. Regional Photochemical Measurement and Modeling Studies, **VIP**-48, *A&WMA*, Pittsburgh, PA., 1043-1063.

Lea, D.A., 1968: Vertical Ozone Distribution in the Lower Troposphere Near an Urban Pollution Complex. *J. Appl. Meteor*, **7**:252-267.

Lonneman, W.A., S.L. Kopezynski, P.E. Darley and F.D. Sutterfield (1974). "Hydrocarbon Composition of Urban Air Pollution." *Environ. Sci. Technol.*, **8**, 229.

Manatt, S. L. and A. L. Lane (1993). "A Compilation of the Absorption Cross-Sections of SO_2 from 106 to 403 nm." *J. Quant. Spectrosc. Radiat. Transfer* **50**, 267-276.

Martin, R.S., H. Westberg, E. Allwine, L. Ashman, J.C. Farmer, and B. Lamb (1991). "Measurement of Isoprene and its Atmospheric Oxidation-Products in a Central Pennsylvania Deciduous Forest." *J. Atmos. Chem.*, **13**, 1-32.

Mass, C.F. and M.D. Albright, 1989: Origin of the Catalina Eddy. *Mon. Weather. Review*, **117**:2406-2436.

Mayrsohn, H. and J.H. Crabtree (1976). "Source Reconciliation of Atmospheric Hydrocarbons." *Atmos. Environ.*, **10**, 137.

Mayrsohn, H., J.H. Crabtree, M. Kuramoto, R.D. Sothern and S.H. Mano (1977). "Source Reconciliation of Atmospheric Hydrocarbons - 1974." *Atmos. Environ.*, **11**, 189.

McElroy, J.L., E.L. Richardson, W.H. Hankins and M.J. Pearson (1982). "Airborne Downward-Looking LIDAR Measurements During the South Coast Air Basin/Southeast Desert Oxidant Transport Study." Data Dept. Env. Mon. Systems Lab., U.S. Environmental Protection Agency, TS-AMD 82133.

McElroy, J. L. and T. B. Smith (1993). "Creation and Fate of Ozone Layers Aloft in Southern California." *Atmos. Environ.* **27A**, 1917-1929.

McElroy, J. L., H. Moosmüller, R. M. Jorgensen, C. M. Edmonds, R. J. Alvarez, II, and D. H. Bundy (1994). "Airborne UV-DIAL Urban Plume Measurements." In Tunable Diode Laser Spectroscopy, Lidar, and DIAL Techniques for Environmental and Industrial Measurement, *Proc. SPIE* **2112**, 251-260. A. Fried, D. K. Killinger and H. I. Schiff (Eds.).

McRae, G.J., F.H. Shair and J.H. Seinfeld (1981). "Convective Downmixing of Plumes in a Coastal Environment." *J. Appl. Meteorol.*, **20**, 1312.

MDAPTC (1996). Interim Report, submitted to California Air Resources Board, February 2, 1996. Copies

available from Environmental Department, Riverside Cement Company, P.O. Box 56040, Riverside CA 92517.

Measures, R. M. (1984). Laser Remote Sensing. John Wiley & Sons, Inc. (New York).

Miller, A. and D. Ahrens (1970). "Ozone Within and Below the West Coast Temperature Inversion." *Tellus*, **22**, 328.

Miller, D.F., D.E. Schorran, T.E. Hoff, D.P. Rogers, W.H. White and E.S. Macias (1990). "An Analysis of Regional Haze Using Tracers of Opportunity." *J. Air Waste Manage. Assoc.* **40**, 757.

Mirabella, V. and M Nazemi (1989). "Development of the SCAQS Emission Inventory: An Overview." Document 89-111.4, presented at 82nd Annual Meeting, Anaheim, CA. Air & Waste Management Association, Pittsburgh, PA.

Molina, L. T. and M. J. Molina (1986). "Absolute Absorption Cross Sections of Ozone in the 185- to 350-nm Wavelength Range." *J. Geophys. Res.* **91**, 14501-14508.

Moore, G.E., S.G. Douglas, R.C. Kessler, and J.P. Killus, (1991). "Identification and tracking of polluted air masses in the South-Central Coast Air Basin." *J. Appl. Met.*, 30:715-732.

Moosmüller, H. (1994). "Analysis of UV-DIAL Data Acquired During the 1993 COAST Study." Desert Research Institute, University of Nevada System. Final Report to the Texas Natural Conservation Commission.

Moosmüller, H., R. J. Alvarez, II, C. M. Edmonds, R. M. Turner, D. H. Bundy, and J. L. McElroy (1993). "Airborne Ozone Measurements with the USEPA UV-DIAL." In Optical Remote Sensing of the Atmosphere Technical Digest, *Optical Society of America* (Washington, D.C.) **5**, 176-179.

Moosmüller, H., R. J. Alvarez, Jr., R. M. Jorgensen, C. M. Edmonds, D. H. Bundy, and J. L. McElroy (1994). "An Airborne UV-DIAL System for Ozone Measurements: Field Use and Verification." In Optical Sensing for Environmental Monitoring, *Air & Waste Management Association* (Pittsburgh, PA) **SP-89**, 413-422.

Moosmüller, H., D. Diebel, H. Bundy, M. P. Bristow, R. J. Alvarez, II, V. A. Kovalev, C. M. Edmonds, R. M. Turner, and J. L. McElroy (1992). "Ozone Measurements with the U.S. EPA UV-DIAL: Preliminary Results." In Sixteenth International Laser Radar Conference, *NASA Conference Publications* (Hampton, VA) **3158**, 95-98. M. P. McCormick (Ed.).

National Research Council. (1991). *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Academy Press, Washington, D.C., 489 pages.

National Research Council (1993). "Protecting Visibility in National Parks and Wilderness Areas." National Academy Press, Washington, D.C.

Neligan, R.E. (1962). "Hydrocarbons in the Los Angeles Atmosphere." *Archives of Environmental Health*, **5**, 7.

NOAA, (1994). "A Multi-Year Observational Study of Atmospheric Transport Corridors and Processes in California." Prepared for California Air Resources Board, Sacramento, CA, Contract No. A032-145, May 1994.

Oliver, W.R. and S.H. Peoples (1985). "Improvement of the Emission Inventory for Reactive Organic Gases and Oxides of Nitrogen in the South Coast Air Basin, Volume I: Main Report." SYSAPP-85/080, Systems Applications, Inc., San Rafael, CA.

Pack, D.H. and J.K. Angell (1963). "A Preliminary Study of Air Trajectories in the Los Angeles Basin as Derived From Tetroon Flights." *Monthly Weather Review*. **91**, 583.

Pitts, J.N., A.M. Winer, H.W. Biermann and E.C. Tuazon (1984). "Direct Measurement of Nitrous Acid, Nitrogen Dioxide and Formaldehyde in Auto Exhaust by Differential Optical Absorption Spectroscopy. Document #A1-089-32. California Air Resources Board, Sacramento, CA.

Raudy, J. (1990). "Interbasin Transport in California: An Annotated Bibliography." Technical Support Division, California Air Resources Board, 157 pp.

Reible, D.D., J.R. Ouimette and F.H. Shair (1982). "Atmospheric Transport of Visibility Degrading Pollutants into the California Mojave Desert." *Atmos. Environ.*, **16**, 599.

Renzetti, N.A. and R.J. Bryan (1961). "Atmospheric Sampling for Aldehydes and Eye Irritation in Los Angeles Smog-1960." *Atmos. Environ.*, **11**, 421.

Roberts, P.T., S. Musarra, T.B. Smith, and F.W. Lurmann (1992). "A Study to Determine the Nature and Extent of Ozone Precursor Transport in Selected Areas of California." Prepared for the California Air Resources Board by Sonoma Technology, Inc., April 1992.

Rogers, D., H. Bastable, D. Miller, D. Schorran, T. Hoffer, E. Macias, and W. White, 1988: The Greater Los

Angeles Distant Impact Study Final Report. Prepared by Desert Research Institute, Reno, NV, for Southern California Edison, Co., Advanced Research, 2244 Walnut Grove Ave., Rosemead, CA, 91770, September 1988.

Roberts, P.T., S. Musarra, T.B. Smith, and F.W. Lurmann (1992). "A Study to Determine the Nature and Extent of Ozone Precursor Transport in Selected Areas of California." Prepared for the California Air Resources Board by Sonoma Technology, Inc., April 1992.

Rogers, D.P. and H.G. Bastable (1989). "The Transport of Pollutants in Southern California." Preprint Volume of the 6th Joint Conference on Applications of Air Pollution Meteorology, pp. 214-217, Jan. 30-Feb. 3, 1989.

Rosenthal, J., 1972: "Point Mugu Forecasters Handbook", Pacific Missile Range Tech. Pub PMR-TP-72-1, (AD 747-641), Geophysics Branch, Naval Air Warfare Center Weapons Division, Point Mugu, California 93042.

Rothe, K. W., U. Brinkmann, and H. Walther (1974). "Application of Tunable Dye Lasers to Air Pollution Detection: Measurement of Atmospheric NO_2 Concentrations by Differential Absorption." *Appl. Phys.* **3**, 115-119.

Rothe, K. W., U. Brinkmann, and H. Walther (1974). "Remote Measurement of NO_2 Emission from a Chemical Factory by the Differential Absorption Technique." *Appl. Phys.* **4**, 181-182.

Sackinger, P.A., D.D. Reible and F.H. Shair (1982). "Uncertainties Associated with the Estimation of Mass Balance and Gaussian Parameters from Atmospheric Tracer Studies." *J. Air Pollut. Contr. Assoc.*, **32**, 720.

Schorran, D.E., H.E. Klieforth and D.F. Miller (1990). "Visibility Episodes in the Southern Sierra Nevada." Visibility and Fine Particles, AWMA Transactions, TR-17. pp. 509-517.

Schuck, E.A., J.N. Pitts and J.K.S. Wan (1966). "Relationships Between Certain Meteorological Factors and Photochemical Smog." *Intl. J. Air Water Pollut.*, **10**, 689.

Schultz, P. and T.T. Warner (1982). "Characteristics of Summertime Circulation and Pollutant Ventilation in the Los Angeles Basin." *J. Appl. Meteorol.*, **21**, 672.

Seinfeld, J.H. (1986). *Atmospheric Chemistry and Physics of Air Pollution.* John Wiley & Sons, New, NY.

Shair, F.H., E. Sasaki, D. Carlan, G.R. Cass, W.R. Goodin, J. Edinger and G.E. Schacher (1982). "Transport and Dispersion of Airborne Pollutants Associated with the Land Breeze/Sea Breeze System." *Atmos. Environ.*, **16**, 2043.

Shettle, E.P. (1972). "The Transfer of Near Ultraviolet Irradiances Through Smog Over Los Angeles." *Atmos. Environ.*, **6**, 165.

Simmonds, P.G., S.L. Kerrin, J.E. Lovelock and F.H. Shair (1974). "Distribution of Atmospheric Halocarbons in the Air Over the Los Angeles Basin." *Atmos. Environ.*, **8**, 209.

Smith, T.B., D.L. Blumenthal, J.R. Stinson and V.A. Mirabella (1972). "Climatological Wind Survey for Aerosol Characterization Program." Document MRI 72 FR-1000, Meteorology Research, Inc., Altadena, CA.

Smith, T.B., S.L. Marsh and W.H. White (1976). "Analysis of Data from the Three-Dimensional Gradient Study." ARB Contract No. ARB 4-051. Prepared for California Air Resources Board, Sacramento, CA.

Smith, T.B. and F. Shair (1983). "The Impact of Transport from the South Coast Air Basin on Ozone Levels in the Southeast Desert." Contract No. A0-145-32, California Air Resources Board, Sacramento, CA.

Smith, T.B., D. Lehrmann, F.H. Shair, R.S. Lopuck and T.D. Weeks (1983). "The Impact of Transport from the South Coast Air Basin on Ozone Levels in the Southeast Desert Air Basin." Report No. ARB/R 83-183, prepared for the California Air Resources Board, Sacramento, California.

Smith, T.B. and J.G. Edinger (1984). "Utilization of Remote Sensing Data in the Evaluation of Air Pollution Characteristics in the South Coast/Southeast Desert Air Basin." Contract No. ARB-R-84-236. California Air Resources Board, Sacramento, CA.

Smith, T.B., W.D. Saunders and D.M. Takeuchi (1984). "Application of Climatological Analyses to Minimize Air Pollution Impacts in California." Prepared under Contract #AZ-119-32 for California Air Resources Board, Sacramento, CA, by Meteorological Research, Inc., Altadena, CA.

South Coast Air Quality Management District. 1993. Air Quality Standards Compliance Report Vol. 5, No. 12.

"Southern California Air Quality Study Data Analysis Conference. 1993. Proceedings, *Air & Waste Management Association*, VIP-26, 358 pages.

Stedman, D.H. (1989). "Automobile Carbon Monoxide Emissions." *Environ. Sci. Technol.*, **23**, 147.

Stephens, E.R. (1968). "The Marine Layer and its Relation to a Smog Episode in Riverside, California." *Atmos. Environ.*, **2**, 393.

Stephens, E.R. (1969). "Formation, Reactions, and Properties of Peroxyacyl Nitrates (PAN's) in Photochemical Air Pollution." *Adv. Env. Sci. Technol.*, **1**, 119.

Stoeckenius, T.E., P.T. Roberts, Y. Horie, and Smith T.B., 1992. "Development of an Objective Classification Procedure for Bay Area Air Flow Types Representing Ozone-Related Source-Receptor Relationships." Technical Proposal by Systems Application International for the California Air Resources Board, SYSAPP-92/014, January.

Stoeckenius, T.E., G. Yarwood, M.P. Ligocki, J.P. Cohen, S.B. Shepard, R.E. Looker, E.M. Fujita, H.H. Main and P.T. Roberts (1995). Feasibility Study for a 1995-1996 Southern California Air Quality Monitoring Program. Final Report, prepared for Coordinating Research Council, Atlanta, GA by Systems Applications International, San Rafael, CA, January 1995.

Tilden, J., M. Valdez, F. Di Genova, and G. Rubenstein (1991). "Analysis of Ozone in the Southeast Desert Air Basin on the Case Study Day of April 29, 1989. Prepared by Sierra Research, Inc., July 1991.

Tombach, I.H. (1982). "Application of Receptor Modeling to Volatile Organic Compounds." Proceedings, Receptor Models Applied to Contemporary Pollution Problems. Air Pollution Control Association, Pittsburgh, PA.

U.S. Environmental Protection Agency (1991). "Technical Assistance Document for Sampling and Analysis of Ozone Precursors." Atmospheric Research and Exposure Assessment Laboratory, U.S. Enviromental Protection Agency, Research Triangle Park, NC 27711. EPA 600/8-91-215, October 1991.

Wagner, K.K. and N.J.M. Wheeler (1995). "Multi-Species Evaluation of the Urban Airshed Model with the SCAQS Database." *In Southern California Air Quality Study--Data Analysis*, E.M. Fujita Ed., VIP-26, Air & Waste Management Association, Pittsburgh, PA, pp. 264-269.

Wakimoto, R.M., 1987: The Catalina Eddy and its Effect on Pollution Over Southern California., *Mon. Weather. Review*, **115**:837-855.

Watson, J.G., J.C. Chow, Z. Lu and A.W. Gertler. 1993. "Particulate and Gaseous Organic Receptor Modeling for the Southern California Air Quality Study, report to the California Air Resources Board, Contract No. A832-132, November 1993).

White, W.H., E.S. Macias, D.F. Miller, D.E. Schorran, T.E. Hoffer and D.P. Roger (1990). "Regional Transport of the Urban Workweek: Methylchloroform Cycles in the Nevada-Arizona Desert." Geophys. Res. Letters, **17**, 1081.

Winer, A.M., D.R. Fitz, P.R. Miller, R. Atkinson, D.W. Brown, W.P.L. Carter, M.C, Dodd, C.W. Johnson, M.A. Myers, K. Neisess, M.P. Poe and E.R. Stephens (1983). "Investigation of the Role of Natural Hydrocarbons in Photochemical Smog Formation in California." Final Report AO-056-32, prepared for California Air Resources Board, Sacramento, CA, by Statewide Air Pollution Research Center, University of California, Riverside, CA.

Witz, S. and A.B. Moore (1981). "Effect of Meteorology in the Atmospheric Concentrations of Traffic-Related Pollutants at a Los Angeles Site", *J. Air Pollut. Contr. Assoc.*, **31**, 1098.

Witz, S., A.M. Larm, B.M. Elvin and A.B. Moore (1982). "The Relationship Between Concentrations of Traffic-Related Pollutants and Meteorology at a Los Angeles Site." *J. Air Pollut. Contr. Assoc.*, **32**, 643.

Yotter, E.E. and D.L. Wade (1989). "Development of a Gridded Motor Vehicle Emission Inventory for the Southern California Air Quality Study." Reprint No. 89-137.2. Presented at 82nd Annual Meeting, Anaheim, CA. Air & Waste Management Association, Pittsburgh, PA.

Zeldin, M.D., R.J. Countess, J.G. Watson, and R.J. Farber (1989). "Review of Meteorological and Co-pollutant Factors on High PM_{10} Concentrations in the South Coast Air Basin." Reprint No. 89-33.4. Presented at 82nd Annual Meeting, Air & Waste Management Association, Anaheim, CA.

Zhao, Y., R. M. Hardesty, and J. E. Gaynor (1994). "Demonstration of a New and Innovative Ozone Lidar's Capability to Measure Vertical Profiles of Ozone Concentration and Aerosol in the Lower Troposphere." National Oceanic and Atmospheric Administration, Environmental Technology Laboratory, Atmospheric Lidar Division. Final Report to the California Air Resource Board, Research Division, **ARB-R-92-328**.

Zhao, Y., R. M. Hardesty, and M. J. Post (1992). "Multibeam Transmitter for Signal Dynamic Range Reduction in Incoherent Lidar Systems." *Appl. Opt.* **31**, 7623-7632.

Zhao, Y. (1991). "Simplified Correction Technique for Backscatter Errors in Differential Absorption Lidar Measurements of Ozone." In Technical Digest on Optical Remote

Sensing of the Atmosphere, *Optical Society of America* (Washington, D.C.) **18**, 275-277.